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MILITARY POTENTIAL TEST OF COMMERCIAL OFF-THE-SHELF HELICOPTERS--ETC(U)
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US ARMY TEST & EVALUATION COMMAND

REPORT OF TEST

USATECOM PROJECT NO. 4-3-1000-02-A

MILITARY POTENTIAL TEST OF COMMERCIAL OFF-THE-SHELF HELICOPTERS AS BASIC ROTARY-WING INSTRUMENT TRAINERS

~~FOR OFFICIAL USE ONLY~~

US ARMY

AVIATION TEST BOARD

FORT RUCKER, ALABAMA

ERRATA

REPORT OF TEST

USATECOM PROJECT NO. 4-3-1000-02-A

Page No.	Para. No.	Change
I-5	I-3	Amend to read "Representatives of the test agencies (including, but not limited to, the US Army Aviation School, the US Army Board for Aviation Accident Research, the US Army Aeromedical Research Unit and the US Army Aviation Test Board) be present when the unsuitable areas and the manufacturers' revised technical proposals are discussed with the listed manufacturers (see code sheet)."
II-10 II-59 and II-154	Cld (2) Cld (3)	Change "octane" to "performance number".
II-12 and II-61	N/A	In Note paragraph, line 7, change "their" to "his".
II-15	1.3	Add in Remarks column, "An FAA Type Certificate was issued for this model helicopter on 18 September 1963."
II-18 and II-114	3.5.2	Add in Remarks column "Heater was placarded against operation during hover."
II-18	3.6	Under Remarks, delete "The IH-1 was operated on 115/145 Octane gasoline and Army nondetergent oil during conduct of the test."
II-18	3.7	In Remarks column add, "No provisions were made for an instructor pilot map light. Instrument and radio control panel lighting could not be independently controlled. Reflections from the instrument panel lights were observed on the bubble. Warning and caution lights could not be dimmed for night operation."

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JE Mallory
USAADTA (PROV)
13 Apr 76
AR 340-16

Page No.	Para No.	Change
II-19	3.7.1	In Remarks column, after 6th item, add "(see paragraph C.2.c(1))" after the word "unsuitable".
II-21 and II-117	3.8.3	In Remarks column, add, "Location of collective-pitch stick friction was not satisfactory with left-right seating proposed. Location of manifold pressure bleed-air control was undesirable."
II-21	3.9.1	In UH-1 Meets Spec column, add an asterisk (*) after "Undetermined".
II-21, II-71, II-118, and II-166	3.9.1	In Remarks column, delete paragraph.
II-22, II-71, and II-118	3.9.2	In Remarks column, delete paragraph.
II-22	3.10.1	In IH-1 Meets Spec column, add "Yes".
II-22 and II-119	3.10.1	In Remarks column, add "Ventilation was not proposed in the after electronic compartment."
II-23 and II-119	N/A	In Remarks column following VOR-Aircraft Radio Corporation add, "Use of ram's horn antenna (AS-580A) as proposed has proven unsatisfactory in helicopters in the past."
II-26	D1	Change "judgements" to "judgments".
II-26	D2a(1)	Delete paragraph, and renumber succeeding paragraphs.
II-37	15	Delete asterisks, and add, "Are spare lamps provided in sufficient quantity and easily accessible? N/A "
II-38 and II-86	21	Amend to read, "Is the auxiliary light adequate for reading? Yes "

Page No.	Para No.	Change
II-49	4.b	Amend to read, "...stability during flight with all systems operating is excellent."
II-66	3.3.1 and 3.3.2	In Remarks column, delete paragraphs.
II-67	3.5.2	In IH-2 Meets Spec column, change, "Yes" to "Undetermined".
II-68	3.6	In Remarks column, delete paragraph.
II-68	3.7	In Remarks column, add "Location of map light was unsatisfactory. Fuel, oil, hydraulic, and electrical system warning lights were not utilized on the instrument panel."
II-70	3.8.3	In Remarks column, add "Secondary cockpit controls were not arranged for access by the student. Ignition switch was located so that it was susceptible to accidental activation."
II-88	3d	Amend last sentence to read, "Approaching 25-30% CO in blood definite changes...."
II-105	C1a(6)	Amend to read, "...was satisfactory except for the obstruction by the pilot and copilot door frames."
II-115	3.6	Change "octane" to "performance number".
II-115	3.7	In Remarks column, add, "Instrument and radio control panel lighting could not be independently controlled."
II-116	3.7.2.a	In IH-3 Meets Spec column, add "Yes".
II-123	D1e	Change "unsuitable" to "unsatisfactory".
II-123	D2	Add paragraph "j. Heater could not be operated at a hover."

Page No.	Para No.	Change
II-129	12	Change "No" to "Yes".
II-130	N/A	Add new paragraph, "15. Are spare lamps provided in sufficient quantity and readily accessible? N/A " and renumber succeeding paragraphs.
II-143	4.c	Amend to read "...from the cockpit is excellent except for the obstruction by the pilot and copilot door frames."
II-150	C1a(1)	Amend to read, "...the manufacturer deviated from the electronic configuration...."
II-152	C1a(6)	Change "of" to "by".
II-154	C1d(6)	Amend to read, "Special tools not in the Army inventory are required...."
II-156	C2e(5)	Amend to read "...shown in the technical proposal were not accessible and...."
II-157	2f	Change "unsatisfactory" to "unsuitable".
II-160	3.1	In Remarks column change "substituted for" to "proposed in lieu of".
II-161	3.3.1	In Remarks column, amend to read "...2.1 hours, utilizing FAA-approved cruise leaning procedures (Paragraph C1c(2))."
II-161	3.3.2	In Remarks column, amend to read "Use of required equipment outlined in appendix I of Model Specification places the weight of the helicopter at 90 pounds over the maximum certificated gross weight. Maximum cabin load authorized was 400 pounds."
II-162	3.6	In Remarks column, change "octane" to "performance number".

Page No.	Para. No.	Change
II-163	3.7	In Remarks column, amend to read "Cockpit and instrument panel illumination was not adequate. Instrument lighting proposed was unsatisfactory. No provisions were made for a map light. Cockpit instrument lighting was reflected in the canopy. Instrument and radio control panel lighting could not be independently controlled. Engine instruments were unsatisfactory."
II-166	3.8.3	In Remarks column, add "In addition, the engine could be started with the rotor-engage lever in the 'engage' position."
II-166	3.8.3 (3d par)	In IH-4 Meets Spec column, change "Yes" to "No" and in Remarks column, add "A two-position ICS/transmit switch on the cyclic stick was not included in the technical proposal."
II-166	3.9.1	In Remarks column, delete paragraph.
II-167	3.9.3	In Remarks column, add "Adjustment for the control pedals was unsatisfactory."
II-168 and II-169	N/A	In Remarks column under navigation requirement, amend to read "ARC 319A proposed is unacceptable." "ARC B-19A proposed is unacceptable." "ARC 318A proposed is unacceptable." "ARC 502A proposed is unacceptable." "C-6-X proposed is unacceptable."
II-172	D1h and D1j	Change "unsuitable" to "unsatisfactory".
II-172	D1	Add paragraph, "p. A stop was not provided on the mixture control to prevent accidental fuel starvation."
II-172	D2	Delete paragraphs "b" and "c" and re-identify succeeding paragraphs.
II-189	2b(3)(a)	Amend third line to read "...in excess of 28 inc. HG manifold...."

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UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama

Project Officers:

(10) Willie S. Davis
~~Major, TC~~

John F. Comer
Captain, TC

(11) 13 NOV 63

REPORT OF TEST

(12) 201 p.

(6) USATECOM PROJECT NO. 4-3-1000-02-A

MILITARY POTENTIAL TEST OF COMMERCIAL OFF-THE-SHELF HELICOPTERS AS BASIC ROTARY-WING INSTRUMENT TRAINERS

036 500

UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama

REPORT OF TEST

USATECOM PROJECT NO. 4-3-1000-02-A

MILITARY POTENTIAL TEST OF COMMERCIAL OFF-THE-SHELF HELICOPTERS AS BASIC ROTARY-WING INSTRUMENT TRAINERS

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UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama

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USATECOM PROJECT NO. 4-3-1000-02-A

MILITARY POTENTIAL TEST OF COMMERCIAL OFF-THE-SHELF HELICOPTERS AS BASIC ROTARY-WING INSTRUMENT TRAINERS

CODE SHEET

This code sheet will be removed when this report is distributed outside the Department of Defense.

Code	Helicopter Designation
IH-1	Hiller UH-12L
IH-2	Bell 47G-3B-1
IH-3	Hiller UH-12E
IH-4	Hughes 269A-1

	Manufacturer
Company A	Hiller Aircraft Company
Company B	Bell Helicopter Company
Company C	Hughes Tool Company, Aircraft Division

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PART I - GENERAL

A. REFERENCES. A complete list of references is contained in part III.

B. AUTHORITY.

1. Directive. Message, TT11128, US Army Test and Evaluation Command, 28 June 1963.

2. Purpose. To determine which commercial off-the-shelf, FAA-certificated helicopters are suitable for use as basic rotary-wing instrument trainers.

C. BACKGROUND. In November 1962, the Deputy Chief of Staff for Operations (DCSOPS) directed the US Continental Army Command (USCONARC) to submit a Statement of Requirement for a commercially-produced, off-the-shelf helicopter to replace tactical helicopters presently in use as instrument trainers at the US Army Aviation School (USAAVNS). In compliance with this directive, USCONARC prepared and submitted the Statement of Requirement in December 1962. In February 1963, the Director of Army Aviation, Office, DCSOPS, forwarded the approved Statement of Requirement to the Commanding General, US Army Materiel Command (USAMC) for evaluation and procurement of an off-the-shelf basic rotary-wing instrument trainer. The CG, USAMC, approved a US Army Mobility Command (USAMOCOM) recommendation for establishment of a two-step procurement program, Invitation for Bids (IFB). Step one of the two-step program consisted of a request for technical proposal from industry, the response of the bidders to the request, and the evaluation by the US Army Test and Evaluation Command (USATECOM) of the bidder's

helicopter and technical proposals to determine the acceptability of the helicopters offered. The second step consists of a formal procurement, in which bid prices will be submitted. Competition in the second step will be strictly confined to the bidders whose helicopter and technical proposals were found acceptable. Step one of the IFB was prepared by the US Army Aviation and Surface Materiel Command (USAAVSCOM) and mailed on 17 May 1963. Delivery to the US Army Aviation Test Board (USAAVNTBD) of one production model helicopter, with a manufacturer's written technical proposal of the configuration which will meet the model specifications, was scheduled for 30 days after receipt of Step One of the IFB by industry. To expedite tests, the schedule of deliveries of the four test helicopters was arranged as follows:

IH-1	10 June 63
IH-2	8 July 63
IH-3	12 August 63
IH-4	26 August 63

Testing of the helicopters was completed on 20 September 1963.

D. DESCRIPTION OF MATERIEL. A description of each test helicopter is contained in part II.

E. TEST OBJECTIVES.

1. The USAAVNTBD evaluated each helicopter to determine:

a. The extent to which each helicopter met the Model Specifications.

b. The extent to which each helicopter met the Statement of Requirement.

c. The physical characteristics and suitability of the overall configuration of each helicopter.

2. The United States Army Aviation School (USAAVNS) evaluated each helicopter to determine mission suitability. The following areas were evaluated:

a. Cockpit configuration.

b. Flight stability.

c. Basic maneuver performance.

d. Adequacy of proposed radio navigation equipment.

F. FINDINGS.

1. None of the helicopters evaluated met completely all requirements contained in the Model Specification and Statement of Requirement.

2. Each helicopter evaluated was found to have deficiencies and shortcomings which adversely affected the suitability of its overall configuration.

3. All helicopters and associated proposals evaluated were found unsuitable for the USAAVNS training mission; however, the IH-1 and IH-2 would not require any major changes to correct the deficiencies and shortcomings noted.

4. The IH-3 was found unsuitable primarily because of deficiencies noted in stability and control forces. Correction of these deficiencies would require major changes.

5. The IH-4 was found unsuitable primarily because of deficiencies noted in endurance, stability, useful load, and control forces. Correction of these deficiencies would require major changes.

G. DISCUSSION.

1. Each manufacturer responding to the IFB was required to furnish the Government one demonstration model of the helicopter(s) proposed. Helicopters not FAA certificated will not be considered

for this procurement. However, a helicopter nearing type certification was considered eligible for the evaluation, provided it had satisfactorily completed the FAA Type Inspection Authorization, Type Inspection Report, and FAA flight test. The technical proposals were required to include written details of how the helicopter will be modified to meet the specification and engineering requirements of the IFB. Any proposed modification must be FAA approved before Step Two is issued, but these modification(s) must not require recertification of the aircraft.

2. The demonstration helicopters furnished for test were not configured as the manufacturer's final product; therefore, these reports judge the suitability of the test aircraft as they would be modified by the manufacturer's technical proposal.

3. Status and progress of the project were reported through periodic reports to US Army Test and Evaluation Command (USATECOM) and the USAAVSCOM.

H. CONCLUSIONS.

1. The IH-1 and IH-2 after correction of deficiencies and shortcomings listed in Units A and B, Part II, should be suitable for Army use as basic rotary-wing instrument trainers.

2. The IH-3 and IH-4 are not suitable for Army use as basic rotary-wing instrument trainers.

I. RECOMMENDATIONS. It is recommended that:

1. The IH-1 and the IH-2 and associated proposals, after elimination of the deficiencies and shortcomings listed in Units A and B, Part II, be considered qualified for Step Two of the procurement program.

2. The IH-3 and IH-4 and associated proposals be considered not qualified for Step Two of the procurement program.

3. Representatives of the test agencies (including but not limited to the USAAVNS, USABAAR, and USAAVNTBD) be appointed members of the Contract Awards Board for procurement of basic rotary-wing instrument trainers to assure detailed correction of deficiencies and shortcomings noted in this report.

A. J. RANKIN
Colonel, Armor
President

PART II - TEST DATA

UNIT A - COMPANY A MODEL IH-1

SECTION ONE

USAAVNTBD REPORT

A. Description of Materiel.

1. The IH-1 is a single-engine, three-place, side-by-side, two-bladed single main rotor and tail rotor type helicopter. Power is supplied by a VO 540-C2A vertically-mounted, six-cylinder, opposed-type, air-cooled, non-supercharged engine, which has a maximum power rating of 305 b.hp. at 3200 r.p.m. Engine power is transmitted to the rotors through a double planetary reduction transmission. The main rotor mast assembly is set into the transmission, which is bolted to the engine, making the complete assembly one rigid unit. Takeoff shaft connections extend from the transmission to drive the tail (anti-torque) rotor. The helicopter tested was not certificated by the Federal Aviation Agency and had not been issued a Type Inspection Report (TIR) by the FAA.

2. Flight controls consist of a cyclic stick, collective pitch stick, and antitorque pedals. The collective and cyclic controls are power boosted with hydraulic cylinders which have a lock and load limiting feature. A cyclic trim system is provided which incorporates a spring in series with a magnetic brake which is normally engaged to react the spring force. A button on the cyclic grip is used to retrim the cyclic stick at a desired position. A two-channel Stability Augmentation System (SAS) is installed and provides low-authority (approximately 10 percent) roll and pitch stabilization. An adjustable friction device is provided for the collective pitch.

3. The main-rotor system is a two-bladed, teetering, underslung rotor. The rotor cuffs which retain the blades are attached to the hub through a set of four angular contact ball bearings and a needle bearing which allows the blades to cycle about the feathering axis. The all-metal main-rotor blades have a constant chord. A two-bladed, all-metal, antitorque tail rotor mounted on flapping hinges provides a means for directional control.

4. The helicopter basic body section and tail boom are of all-metal stressed-skin construction with a tinted plexiglass bubble. A

skid-type landing gear, with removable conventional ground-handling wheels, is used on the helicopter.

5. General dimensions of the IH-1 are listed below:

a.	Overall height	10 feet 2 inches
b.	Overall length (main rotor tip to tail rotor tip)	40 feet 6 inches
c.	Rotor diameter	35 feet
d.	Fuselage width	4 feet 11 inches
e.	Skid gear tread	7 feet 6 inches

6. Company A submitted two separate instrument trainers in their technical proposal: the IH-1(3) and the IH-1(5). The IH-1(3) is the IH-1 described above, modified as an instrument trainer. The IH-1(5) differs only in the length of the cabin area. This additional length, approximately 20 inches, proposed in the IH-1(5) version, allows for a third seat for a student observer, if desired, in the center behind the student and instructor pilot seats.

B. Scope of Tests. The test was conducted in the vicinity of Fort Rucker, Alabama, by USAAVNTBD project officers and USAAVNS rotary-wing instrument instructor personnel. The test consisted of three phases: a 25-flying-hour evaluation; a thorough study of the manufacturer's technical proposals which described changes to be made to configure the test helicopter to meet the stated requirements; and a comparison of the helicopter with the Model Specifications and the Statement of Requirement. In addition, the US Army Board for Aviation Accident Research (USABAAR) evaluated the aviation safety aspects; the US Army Aviation Human Research Unit (USAAHUMRU) evaluated the human factor aspects; and the US Army Aeromedical Research Unit (USAARU) evaluated noise level, internal lighting, and heating and ventilation. Complete reports as received from each of these units are contained in section two.

C. Tests.

1. Evaluation of Physical and Flight Characteristics, Performance, and Maintenance.

a. Physical Characteristics.

(1) Basic Weight. The basic weight was determined by weighing the helicopter as delivered with oil and trapped fuel. To this weight (1918 pounds), the weight of electronic and auxiliary equipment required for Army use (212 pounds) was added, and the weight of currently-installed equipment not required for Army use (83 pounds) was subtracted, resulting in a total basic weight of 2047 pounds. These figures are applicable only to the IH-1(3) proposal. The estimated mission operating weight was then computed by adding to the estimated basic weight 276 pounds (main fuel), 140 pounds (auxiliary fuel), and 450 pounds (instructor, student, and instructional equipment). Details follow:

EMPTY WEIGHT as weighed (less ground-handling wheels)	1918 lb.
Weight of required equipment to be added:	
Shoulder harness and inertia reel (2 each)	6
First-aid kit and fire extinguisher	10
AN/ARC-45 UHF	27
C-1611 interphone (2 each)	4
VOR, Type 15F	27
ADF, Type 21A	23
MB/GS	9
Heading Reference, SPC-1	5
RMI, Sperry C-6-H	5
Generator, 125 amp.	38

RMI Converter, B-18A	4	
Instrument Training Hood	5	
Antenna, AT-450/ARC	1	
Battery, MA-7	34	
Inverters (2 each)	14	
TOTAL ADDED	212 lb.	212 lb.
		2130 lb.

Weight of installed equipment to be removed:

Commercial radio	8	
Rate gyro	1	
Transformer	2	
Directional gyro	3	
Inverter	7	
Misc. plumbing	4	
Generator, 50 amp.	20	
Auxiliary fuel tank plumbing	10	
Battery	28	
TOTAL SUBTRACTED	83 lb.	83 lb.
BASIC WEIGHT (estimated)		2047 lb.
Fuel (main tank)	276 lb.	
Auxiliary fuel and 20-gallon tank (estimated)	140 lb.	

Instructor pilot, student, and instructional equipment	450 lb.	
	866 lb.	866 lb.
MISSION OPERATING WEIGHT (estimated)		2913 lb.
REMAINING AVAILABLE PAYLOAD		187 lb.
MAXIMUM CERTIFICATED GROSS WEIGHT		3100 lb.

The manufacturer's estimate of basic weight for the IH-1(5) (extended pan, 2 x 1 seating) proposal is 2089 pounds.

(2) Ground-Handling Characteristics. Ground-handling characteristics were satisfactory, utilizing the removable ground-handling wheels provided with the helicopter.

(3) Adequacy of the Cockpit Configuration and Arrangement. The cockpit configuration and arrangement of the test helicopter were evaluated except those items changed in the manufacturer's technical proposal. The cockpit configuration and arrangement were satisfactory except for the following:

(a) Collective throttle friction required rotation in a clockwise direction to tighten. Engine power can inadvertently be decreased when increasing throttle friction.

(b) No provisions were made to turn off the cyclic control force trim.

(c) The location of hydraulic boost by-pass switch required the pilot to release the collective control to turn off the system in the event of malfunction.

(d) Installed seat belts did not meet military specifications.

(4) Noise Level. Overall internal and external sound pressure levels were acceptable. However, numerous internal measurements exceed the military specification for acoustical noise levels in Army aircraft (MIL-A-8806) (paragraph A, section two).

(5) Suitability of External Lighting. External lighting was satisfactory and met the Model Specification.

(6) In-Flight Visibility. Visibility from the instructor-pilot seat was satisfactory except for the pilot and copilot doors. Heavy acetate, zip-up windows were provided on the upper half of both the left and right cockpit doors. The cloth edging required to hold the zipper, combined with the top of the door and frame, restricted lateral visibility. In addition, the window material is susceptible to scratching, marring, and discoloring which would restrict and distort in-flight visibility.

(7) Heating and Ventilation. An accurate evaluation of the heating system could not be accomplished because facilities were not available at Fort Rucker to control outside air temperature. Ventilation was adequate (paragraph A, section two).

(8) Suitability for Hoisting, Jacking, and Mooring. The helicopter was equipped with suitable jacking points and had suitable locations on the structure for attachment of mooring lines. Special hoisting straps, presently in the Army system, are required for hoisting the helicopter.

(9) Suitability of External Power Receptacle. The helicopter was equipped with an external power receptacle that was compatible with the Army's APU's.

(10) Center-of-Gravity Travel. The CG of the helicopter remained within limits without addition of ballast or relocation of components regardless of changes in loading of the helicopter with respect to fuel, instructor pilot, and student.

b. Flight Characteristics. The helicopter was flown at weights varying from mission operating weight (2913 pounds) to maximum certificated gross weight (3100 pounds). Maneuvers normally required by a rotary-wing basic instrument trainer were performed with particular attention toward controllability and in-flight stability. The flight characteristics of the IH-1 as a basic instrument trainer were satisfactory except for the following:

(1) Controllability.

(a) Force trim (cyclic stick centering device) installed on the IH-1 required an abnormal amount of pressure to

overcome force trim stick forces. A gradient spring of weaker force would be necessary to use force trim. In addition, no provisions were made to turn off the force trim.

(b) With hydraulic boost turned off, a definite lateral instability problem existed. Because of this instability, hover flight was extremely tiring and dangerous from the standpoint of controllability. In cruise flight with the hydraulic boost turned off, control forces were acceptable. Autorotations were not attempted with the hydraulic boost turned off because of the lateral instability problem.

(c) Controllability without the SAS installed was unsatisfactory.

(d) Large changes in pitch attitude were required for transition from a hover to a cruise of 70 knots. These attitude changes are undesirable for student instrument training but are considered normal for a helicopter of this size.

(2) In-Flight Stability. The stability of the IH-1 was evaluated in pitch, roll, and yaw. Smooth to lightly turbulent air was encountered during the flight test period. The helicopter was stabilized in the pitch and roll axes by SAS, and stability in these axes was satisfactory. In light turbulence, the IH-1 was unstable about the yaw axis. Consequently, increased yaw instability could be expected in moderate turbulence. Overall stability of the helicopter was rated unsatisfactory with SAS on. Stability around all axes with the SAS off was unsatisfactory.

(3) Autorotational Characteristics. Autorotational characteristics were considered above average due to the high-inertia rotor system. During the autorotative approach, a slight instability was encountered about the roll axis. This instability was not considered significant during contact flight but could present a problem for a student flying under simulated instrument conditions.

c. Performance. The helicopter was flown at both mission operating weight (2913 lb.) and maximum certificated gross weight (3100 lb.) to determine whether it met the performance criteria as specified by the Model Specification. The following were determined:

(1) Maximum cruise airspeed (true) at 5000 feet m.s.l. (standard conditions) was 79 knots.

(2) Endurance at 5000 feet m. s. l. (standard conditions) at 70 knots (true airspeed) was 2.3 hours at 3100 pounds and at 2750 pounds gross weight. Taking into consideration the capacity of the auxiliary tanks listed as available in the proposal, the following endurance could be obtained:

One auxiliary tank	3.3 hours (estimated)
Two auxiliary tanks	4.2 hours (estimated)

d. Maintenance.

(1) During the evaluation, the helicopter was maintained by the manufacturer's representative with military personnel provided for servicing, general assistance, and maintenance of records.

(2) Engine operation on standard Army fuel (115/145 octane) and lubricants was satisfactory.

(3) The main rotor system is of such recent design that actual component life of the rotor system has not been determined by the manufacturer. No significant problems were encountered during the evaluation.

(4) The helicopter was easy to service and maintain. All major components were readily accessible; however, no replacements were required during the evaluation.

(5) Tools and ground support equipment normally found at the organizational level were adequate for organizational maintenance. Special tools are required for higher echelons of maintenance.

2. Evaluation of Manufacturer's Technical Proposal. A thorough study was made by the manufacturer's technical proposal which described changes to reconfigure the test helicopter to meet the stated requirements. The following was determined:

a. Adequacy of the Cockpit Configuration and Arrangement as Proposed. The cockpit configuration and arrangement of the IH-1(3) (left-right seating) and the IH-1(5) (2 x 1 seating) technical proposals were considered.

(1) The position of the manifold pressure bleed-air control was undetermined in the technical proposal. The location in the test helicopter on the left side of the instrument console was undesirable.

(2) Detailed location of available storage space was not included in the manufacturer's technical proposal; however, the cockpit appeared large enough for adequate storage of instructional material.

(3) Location of collective stick friction was not satisfactory with left-right seating proposed. Position of collective friction was undetermined with the IH-1(5) seating arrangement.

(4) No provisions were made for seat adjustments in the IH-1(5) proposal.

(5) Adjustable control pedals included in the technical proposal were satisfactory.

(6) Seat belts and shoulder harnesses with inertia reels for all occupants were included in the technical proposal; however, suitability could not be determined.

(7) Floor-mounted and cyclic-control-mounted radio-interphone switches were provided for both student pilot and instructor. No provisions were made for student-observer intercom in the IH-1(5) proposal.

(8) Drawings of the instrument training hood in the manufacturer's technical proposal appeared to provide a satisfactory approach to the problem of providing an instrument training hood. A mockup of the hood was not provided; therefore, a determination of its suitability could not be made. The instrument training hood appeared to provide a minimum of obstruction to the instructor pilot's outside vision. Additional consideration should be given to providing a shield for the lower part of the student pilot's door to prevent possible visual distraction. Material proposed and method of installation of the instrument training hood appeared to be satisfactory; however, it would be more desirable if the panels installed on top of the instrument console could be collapsed for increased student visibility in the event of an emergency.

b. Suitability of Internal Lighting. The cockpit and instrument panel illumination met Model Specification requirements although numerous unsatisfactory conditions were noted (paragraph A, section two).

c. Instrumentation and Panel Arrangement Proposal.

(1) The manufacturer's proposal for a production panel configuration and instrument arrangement was satisfactory except for the turn-and-slip indicator.* The use of an attitude indicator (AR-1C) with an integral horizontal bar turn-and-slip indicator which was proposed is considered unsuitable. If operating on partial panel, no reference is available to determine the rate of turn when greater than standard rate, because the maximum travel of the turn indicator is limited to turns slightly greater than standard rate.

(2) A manifold pressure indicator and engine tachometer were provided.

(3) The instrument panel was configured in a front-mounted panel standard "T" arrangement.

(4) All flight and navigational instruments required by the Model Specification were provided.

(5) Switches and auxiliary controls necessary for flight and navigation as shown in the technical proposal were accessible and were within reach of the student pilot and instructor.

(6) The radio control panel as shown in the technical proposal was accessible, both visually and physically, to the student and instructor pilot.

(7) No information was available to determine suitability of the proposed SPC-1 heading reference.

d. Mission Suitability. The IH-1 as proposed was unsuitable in the area of mission suitability. (See paragraph B, section two, for the complete report from the USAAVNS.)

*The manufacturer provided a temporary installation of the proposed five-inch attitude indicator which included a four-minute turn-and-slip indicator. Considerable difficulty was experienced interpreting rate of turn because of the helicopter yaw instability which resulted in a rapid oscillation of the turn indicator. This problem was partially alleviated by the installation of an oscillation damper that slowed the needle rate on the turn indicator. The manufacturer has revised their proposal to include a rate damper in production aircraft.

e. Electronic Configuration. The helicopter provided for evaluation was not equipped with the electronic equipment specified in appendix I of the Model Specification. The manufacturer's proposal submitted with the helicopter specified the location and installation of all electronic components. The proposed electronic configuration was unsatisfactory because of the following:

(1) The ram's horn VOR antenna with the combined ILS glide slope antenna (AS-580A) is located on the top of the bubble. This antenna and location indicate probable unsatisfactory performance due to rotor modulation. (See USAAVNS report, paragraph B, section two, for additional information.)

(2) No provisions were indicated for ventilation of the after electronic compartment in which the proposed electronic equipment will be installed.

f. Aviation Safety. The evaluation considered the categories of operational safety, maintenance safety, and crashworthiness. In each of these categories, USABAAR found the aircraft to be acceptable for its intended mission. Certain discrepancies which would detract from its mission capability were noted (see paragraph C, section two, for complete report).

g. Human Factors. The arrangement of the instrument panel is regarded as less than optimum from the instructor's standpoint. The 2 x 1 seating arrangement of the IH-1(5) is not considered desirable for the basic instrument training mission. Sideward visibility is too restricted by the wide door trim. (See paragraph D, section two, for complete report.)

3. Comparison with Model Specification and Statement of Requirement. The extent to which the IH-1 met the requirements of the Model Specification and Statement of Requirement was determined by consideration of the characteristics of the helicopter as tested and an evaluation of the manufacturer's technical proposal.

a. Comparison with Model Specification as Amended.

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
1.	SCOPE.		

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
1.1	Scope. This detail specification covers the essential requirements for the design of a single engine Helicopter Basic Instrument Trainer capable of performing the mission specified in 1.2.		
1.1.1	Designation and General Description.		
	Army Model Designation - Helicopter Basic Instrument Trainer (model number not yet assigned).		
	Number of crew - 1 pilot	Yes	
	Number of passengers - 1 student	Yes	IH-1(5) proposal has seating arrangement for 2 students and 1 instructor pilot.
	Crew and passenger seating arrangement - side by side (instructor pilot on the left).	Yes	
	Flight controls - dual	Yes	
	Main rotor system - single	Yes	
1.2	Mission. The primary Army mission for which this helicopter will be employed is training of military pilots in helicopter	No	See USAAVNS report for complete details (paragraph B, section two).

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
	instrument flying. Training will be accomplished under simulated instrument flight conditions.		
1.3	Federal Aviation Agency Certification. The helicopter will have a part 6 standard airworthiness certificate issued by the Federal Aviation Agency.	No	
1.4	Performance Information. Those items of performance stated as requirements herein which are not included in the FAA approved flight manual are subject to verification by the U. S. Army.	Not Required	
2.	APPLICABLE DOCUMENTS.		
2.1	The documents applicable to this specification are those necessary to fulfill the requirements of paragraph 1.3, Federal Aviation Agency Certification.	No	TIR, flight handbook, and maintenance manual were not applicable to the test helicopter.
3.	REQUIREMENTS.		
3.1	Basic Weight. The basic weight of the helicopter will include all required installed equipment including the avionics as stated in paragraphs 3.7.1, 3.8.1.1, and 3.10.1.	Yes	

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
3.2	Center-of-Gravity Travel. Addition, removal, or relocation of ballast or aircraft components will not be necessary in order to maintain the CG within CG limits due to changes in loading of the helicopter with respect to fuel, pilot and student.	Yes	
3.3	Required Performance.		
3.3.1	NASA Standard Day Conditions (at certificated gross weight).		
	Cruise speed (minimum) - 70 knots at 5000 feet m.s.l.	Yes	Maximum cruise speed (V_{max}) obtained was 79 knots.
	Endurance (minimum) - 2 1/2 hours at 70 knots cruise speed at 5000 feet m.s.l.	No	Maximum endurance was 2 1/4 hours. The manufacturer did not propose auxiliary tanks; however, use of one available auxiliary tank provides 3.3 hours and 2 tanks, 4.2 hours (estimated).
3.3.2	Useful Load. The useful load of the helicopter will be sufficient for 450 pounds in addition to fuel and oil	Yes	Limited endurance previously pointed out was a result of main

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
	necessary to accomplish the 2 1/2 hours endurance performance mission specified in paragraph 3.3.1.		fuel tank capacity (see Remarks above). Remaining available payload was 187 pounds with an auxiliary tank.
3.4	Aircraft Structure.		
3.4.1	Landing Gear.		
3.4.1.1	Type Landing Gear. Type of landing gear is optional.	Yes	Skid-type gear was utilized.
3.4.1.2	Ground Handling. Ground-handling wheels are required. Weight of the ground-handling wheels will not be included in the weight empty if they are detachable.	Yes	
3.4.1.3	Hoisting, Jacking, and Mooring. Provisions will be made for hoisting, jacking, and mooring.	Yes*	
3.5	Operating Environment.		
3.5.1	Aircraft Operation. The aircraft will be capable of operating in temperatures from 0°F. to +100°F.	Undetermined	Manufacturer's proposal indicates helicopter is capable of operation in temperatures from 0°F. to +100°F. Temperatures during

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
			test period varied from +75°F. to +95°F. No difficulties were noted.
3.5.2	Cabin Heating. The aircraft will have a heating system which provides a minimum of 50°F. cabin temperature, with 0°F. outside air temperature. This condition need only be satisfied with the engine operating.	Undetermined	A cabin heating system was provided. See US Army Aeromedical Research Unit report, paragraph A, section two.
3.5.3	Defrosters. This aircraft will include defrosters on both sides of the windshield.	Yes*	Defrosters were incorporated with the cabin heater system.
3.6	Fuel and Lubricants. The engine will operate on such fuel and lubricants which are now established as standard by the US Army. (Reference: MIL-G-5572C dated 12 July 1960, MIL-L-22851 dated 30 July 1961, and MIL-L-6082C dated 18 May 1961.)	Yes	The IH-1 was operated on 115/145 octane gasoline and Army nondetergent oil during conduct of the test.
3.7	Instruments and Navigation Equipment. Flight instruments and lights for day and night VFR flight conditions will be furnished and [illegible].	Yes*	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
	installed by the contractor. Standard "T" arrangement, front mounted panel, is required. Instrument panel will be arranged to permit unobstructed vision of instruments by the instructor pilot and student pilot.		
3.7.1	Navigational Group. The following instruments are required.		
	Attitude indicator - five-inch, non-precessing, non-tumbling type.	Yes*	The indicator must have adequate pitch and roll adjustment.
	Heading indicator - three-inch, radio magnetic indicator RMI type.	Yes*	
	Vertical-speed indicator - instantaneous type.	Yes*	
	Altimeter - sensitive, barometric.	Yes	
	Airspeed indicator - (indicated in knots).	Yes*	
	Turn-and-slip indicator - four-minute turn needle.	Yes*	Incorporated in AR-1C attitude indicator but considered unsuitable.

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
	Magnetic compass - located for easy reference by student pilot and instructor pilot.	Yes*	
	Clock - elapsed time.	Yes*	
3.7.2	Power Group.		
	a. For reciprocating engine: a manifold pressure indicator and engine/main rotor tachometer are required.	Yes	
	b. For turbine engine: a gas producer indicator, torquemeter, and engine/main rotor tachometer are required.	N/A	
3.8	Electrical.		
3.8.1	Lighting.		
3.8.1.1	Anti-Collision Light. The aircraft will have an anti-collision light. The light will be located to prevent reflection into the cockpit.	Yes	
3.8.1.2	Landing Light(s). The aircraft will be equipped with landing lights which will be adjustable. The landing light switch will be located on the pilot's cyclic or collective controls.	Yes	Landing light was manually adjustable on the ground.

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
3.8.2	Power Receptacle. The aircraft will be equipped with an external power receptacle of an AN or AMS standard design.	Yes	
3.8.3	Switches and Auxiliary Controls. All switches and auxiliary controls necessary for flight and navigation will be accessible and within reach of the student pilot and the instructor pilot. Switches and controls shall be operable in flight by personnel wearing winter flight clothing. Accessible floor mounted and cyclic control mounted radio-interphone switches will be provided for both student pilot and instructor.	Yes*	
3.9	Other Equipment and Requirements.		
3.9.1	Instrument Training Hood. A permanent type hooded device which will allow the student to observe the instruments and not allow observance outside the aircraft will be provided. This device will not obstruct the vision of the instructor pilot.	Undetermined	It would be more desirable if the panels installed on top of the instrument console could be collapsed for increased student visibility in the event of an emergency (paragraph B, section two).

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
3.9.2	Safety Equipment. Seat belt and shoulder harness for all occupants will be provided.	Yes*	Shoulder harness with inertia reels is provided in the technical proposal.
3.9.3	Control Pedals. Adjustable control pedals will be provided.	Yes*	
3.9.4	Storage Space. Storage space for navigational equipment such as maps, charts, computers, and navigational kit (TM 11-2557) will be provided.	Yes	
3.10	Avionics.		
3.10.1	Electronic Equipment. The aircraft will be equipped with electronic equipment as indicated in appendix I.		
3.10.2	Radio Control Panel. Must be accessible, both visually and physically, to the student pilot and the instructor pilot. Overhead location is not acceptable.	Yes*	
	APPENDIX I		
	Communications.		
	UHF - AN/ARC-45, 1 each	Yes*	
	ICS - C1611, 2 each	Yes*	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
	Navigation.		
	VOR - Aircraft Radio Corp., Type 15F, 1 each	Yes*	
	RMI Converter - ARC Type B-18A, 1 each	Yes*	
	ADF - Aircraft Radio Corp., Type 21A, 1 each	Yes*	
	MB/GS - Collins/Babcock, 1 each. (Marker Beacon Glide Slope Receiver to be commercial counterpart of R-844, if available.)	Yes*	
	Heading reference, 1 each (Contractor selected and furnished systems having capabilities equal to or superior to Army Standard J-2 compass (commercial C-4). Equipment will be furnished with C-6H indicator. The selected system shall be qualified to FAA Technical Standard Order C6C and shall bear TSO Type A certification decals.)	Undetermined*	No information was available to determine suitability of the proposed SPC-1 heading reference.
	Instrumentation.		
	RMI - Sperry C-6H, 1 each	Yes*	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-1 Meets Spec.	Remarks
	Miscellaneous.		
	Antenna - AT-450/ARC, 1 each	Yes*	
	Battery, Sonotone MA-7, 1 each	Yes*	
	Inverter - Leland MG-E-93-200 or Bendix 328-172-1, 2 each	Yes*	Leland MG-E-93-200 is proposed.

b. Comparison with Statement of Requirement. A comparison with the Statement of Requirement (reference 3), excluding those requirements covered by the Model Specification, follows:

Performance. Unless otherwise specified, the following should be attained at NASA standard conditions with an instructor pilot, one student pilot, and fuel for 2.5 hours endurance at normal cruise.

Requirement	IH-1 Meets Requirement	Remarks
Cruise airspeed (standard day) 5000' m.s.l. (knots):		
Essential - 70	Yes	79 knots maximum cruise speed (V_{max}).
Desired - 90	No	
Endurance (at cruise airspeed) 5000' m.s.l., no reserve (hours):		
Essential - 2.5	No	Use of auxiliary tanks provide:
Desired - 3.5	No	1 tank - 3.3 hours (estimated) 2 tanks - 4.2 hours (estimated)

*Not tested; included in technical proposal.

Requirement	IH-1 Meets Requirement	Remarks
Stability - adequate yaw, roll, and pitch stability in light to moderate turbulence.	No	See paragraph B, section two, for details contained in USAAVNS report.
Cabin Arrangement.		
Windshields constructed of material highly resistant to scratching.	Yes	Latest state-of-the-art material is used for bubble. No scratches were acquired during conduct of evaluation.
Warning lights on panel to include fuel, oil, hydraulic, and electrical systems (desired).	Yes*	
Earphone and microphone jacks and cords compatible with APH-5 helmet for all occupants.	Yes*	
Personnel Considerations.		
No new personnel skills will be required.	Yes	Because of the similarity to other helicopters in the Army, no new personnel skills will be required.
Training Considerations.		
No new training requirements will be generated.	Yes	No additional service schools will be required.
No supporting training devices other than those on hand at	Yes	

*Not tested; included in technical proposal.

Requirement	IH-1 Meets Requirement	Remarks
the US Army Training Base are required.		

D. Deficiencies and Shortcomings.

1. IH-1(5). Owing to the lack of information regarding this model, no deficiencies and shortcomings could be ascertained, and no judgements regarding its suitability could be made.

2. IH-1(3).

a. The following deficiencies were noted during conduct of the evaluation:

Deficiency	Suggested Corrective Action
(1) The IH-1 was not flight certificated by the FAA.	Obtain FAA flight certification for the IH-1.
(2) The endurance of the IH-1 did not meet the Model Specification requirement.	Increase internal fuel capacity. The available auxiliary fuel tank is unacceptable from a crashworthiness standpoint.
(3) Use of a ram's horn antenna in helicopters has proved unsatisfactory in the past.	Use the AS-1304 Split Loop VOR antenna and A-326-A ILS Glide Slope Antenna or similar equipment of equal performance in lieu of ram's horn antenna (AS-580A proposed), and locate to provide optimum reception.
(4) Adequate stability was not provided in light-to-moderate turbulence.	Provide adequate three-axis stability augmentation system.
(5) Insufficient lateral stability was provided with hydraulic boost turned off.	Provide increased lateral stability when hydraulic boost is turned off.

Deficiency	Suggested Corrective Action
(6) Force trim could not be turned off.	Incorporate force-trim unit with ON-OFF capability.
(7) Turn-and-slip indicator incorporated in AR-1C attitude indicator was unsuitable.	Install separate standard 3-inch turn-and-slip indicator (4 min.) located below VOR glide-slope indicator.
(8) Location of collective pitch stick friction was not satisfactory with left-right seating proposed.	Relocate collective friction to a position compatible with left-right seating.
(9) No provisions were indicated for ventilation of after electronic compartment.	Provide adequate ventilation.
(10) No provisions were made for an instructor pilot map light to read approach plates.	Provide a standard, detachable map light installed above and to the left of the instructor pilot.
(11) Cyclic stick trim forces were too large.	Reduce gradient spring tension.

b. The following shortcomings were noted during conduct of the evaluation:

Shortcoming	Suggested Corrective Action
(1) Instruments and radio control panel lighting could not be independently controlled.	Provide a rheostat control for flight and engine instruments and one for radio and navigation controls and locate so as to be accessible to both instructor and student.
(2) Cloth edging of acetate windows and the cockpit door frames restricted visibility.	Redesign doors to increase visibility. Door modification should include provisions for sufficient ventilation.

Shortcoming	Suggested Corrective Action
(3) Rotation of collective throttle friction was not standard.	Throttle friction should tighten in the same direction as application of power.
(4) Location of manifold pressure bleed air control was undesirable.	Relocate bleed air control to the face of the instrument panel.
(5) Reflections from instrument panel lights were noted on the right and left side of the bubble.	Prevent reflections from instrument panel lights.
(6) Warning and caution lights should have capability to be dimmed for night operation.	Provide dimming capability.
(7) Short skid shoe installation exposes skid shoes to catch on ground objects.	Provide full length skid shoe installation.
(8) Magnetic chip detectors were not installed in the engine and transmission oil sumps.	Provide magnetic chip detectors.
(9) The tail rotor has no guard extending beyond the blades which would prevent personnel from walking into them.	Install tail rotor guard.

SECTION TWO

Reports from Other Agencies on the IH-1

Paragraph A

Aviation Field Operations Division
US ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama

USAARU-FO 29 July 1963

NOISE EVALUATION OF THE IH-1

1. Methods and Equipment.

a. Due to the number of aircraft to be tested and the short time available, the noise analysis was limited to the following:

(1) "A" - 24-55 db: sound level for speech interference.

(2) "B" - 55-85 db: sound level for noise survey.

(3) "C" - 85-140 db: sound pressure level - over-all frequency response.

b. A General Radio, Sound-Level-Meter, type 1551-C, was used for the noise measurements.

c. The test area, located at County Line Strip, is a pre-marked compass rose with a 50-foot radius.

2. Results. (See Annex A.)

3. Discussion.

	Doors On	Doors Off	MIL-A-8806
Normal cruise	109	114	106
Maximum cruise	110	114	113

a. Operation of this helicopter at normal and maximum cruise with the doors on or off produced excessive sound pressure levels of 109, 110, and 114 which exceed Tables I and IV MIL-A-8806.

b. There are no military specifications for external noise. Raw data is included for purpose of comparison only.

4. Summary. Improvements should be made to reduce noise levels to meet military specifications (MIL-A-8806).

/s/ William C. Thrasher

1 Incl
as

/t/ WILLIAM C. THRASHER
2/Lt., MSC
Ass't Chief, Avn Fld Opns Div

NOISE LEVEL MEASUREMENTS - OCTAVE BAND ANALYSIS

DATA COLLECTION SHEET

Analyzed by Lt. W.C. Thrasher
S/Sgt Lonnie Parsons

14 June 1963

IH-1

DOORS ON	A	B	C	Center	Student	Indic Air Speed	Mani-fold	RPM	Radius
Ground idle	92	100	105		1	-	9.5"	2100	
Ground high power	99	105	109		1	-	16	3200	
Hover	100	106	109		1	-	19.3	3200	
Normal cruise	100	105	109		1	80	22	3100	
Maximum cruise	102	106	110		1	100	24	3200	
DOORS-OFF									
Ground idle	103	102	106		1	-	9.5	2100	
Ground high power	100	107	110		1	-	16	3200	
Hover	102	108	111		1	-	19.3	3200	
Normal cruise	101	107	114		1	80	22	3100	
Maximum cruise	103	109	114		1	100	24	3200	
EXT HIGH POWER							16.0	3200	
0	91	101	104						50'

	A	B	C	Center	Student	Indic Air Speed	Mani-fold	RPM	Radius
30	93	101	103						
60	94	101	103						
90	98	105	108						
120	101	108	110						
150	103	110	112						
180	101	109	112						
HOVER									
0	91	99	105				19.3	3200	50'
30	94	100	104						
60	95	102	106						
90	101	107	109						
120	103	109	111						
150	105	112	115						
180	101	110	113						

ANNEX A

Aviation Field Operations Division
US ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama

USAARU-FO 29 July 1963

LIGHT EVALUATION OF THE IH-1

1. Methods and equipment.

a. The evaluation consisted of in-flight analysis of the aircraft's lighting system under night conditions. Criteria for this evaluation were derived from U. S. Navy Specifications governing cockpit and instrument panel illumination modified to meet Army requirements.

b. A standard Norwood photo-electric meter was used to measure overall cockpit illumination from the auxiliary hand light or map light.

2. Results. (See Annex A.)

3. Discussion.

a. All instruments were adequately illuminated with standard red light with the exception of the lower instrument panel and control console which were completely dark.

b. Reflections from the instrument panel lights were noted on the right and left sides of the bubble. These reflections should be eliminated to assure adequate peripheral vision.

c. Warning and caution lights should be dimmed for night operations in order to safeguard the pilot's night vision.

d. The map light should be mounted in a position convenient for the student to read approach plates and charts while flying the aircraft.

4. Summary. By improving the deficiencies mentioned above, the cockpit illumination of this aircraft could satisfy military illumination standards for a primary and instrument trainer.

/s/ William C. Thrasher
1 Incl /t/ WILLIAM C. THRASHER
2/Lt., MSC
Ass't Chief, Avn Fld Opns Div

Aviation Field Operations Division
US ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama

COCKPIT LIGHT STUDY
IH-1

1. Are all instruments adequately illuminated? No (Note para 3a)

2. Are they illuminated uniformly? No Is there sufficient intensity? Yes

3. Is illumination controllable to very low intensities? Yes (Rheostat)

4. Are markings of instruments readable? Yes

5. Are all controls, instructions, and nameplates adequately illuminated? No (Note para 3a.)

6. Are they illuminated uniformly? No Is there sufficient intensity? No

7. Is illumination controllable to very low intensities? Yes

8. Are markings on controls, instructions, and nameplates readable? No

9. Is the intensity of lighting for some instruments and controls controlled separately? Yes, on auxiliary light.

10. Is flood lighting provided? Yes Is the light standard red? Yes

11. Is the power source independent of normal lighting circuit? Yes

12. Are there any sources of light which give other than standard red light? No

13. Are there any reflections in the windshield, windows, canopy, or other reflecting surfaces which interfere with visibility inside or outside the cockpit? Yes (Note para 3b.)

14. Is there light leakage into the cockpit from other compartments? No

15. * * * * * * *

16. Are all instruments, instructions, nameplates, and control markings readable in daylight? Yes

17. Can warning and caution lights be dimmed sufficiently for night operation? No (Note para 3a.)

18. Are warning and caution lights of sufficient intensity for daylight use? Yes

19. Are warning and caution lights on the main dimming circuit? No

20. Is lighting provided in accordance with the aircraft detail specification? N/A

21. Is the light adequate for reading? Yes

22. Does the light cause glare to cockpit? No

23. Is there adequate general illumination for the compartment? No (Note para 3d.)

24. Do any of the exterior lights provide glare in the cockpit? No

25. Is exterior lighting provided in accordance with FAA? Yes
Map light rated at 32 footcandles with light 14 inches from photometer.

Aviation Field Operations Division
US ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama

USAARU-FO 29 July 1963

REPORT ON IH-1

1. Method of Testing.

a. The heating and ventilation evaluation of the IH-1 consisted of comparisons of outside air temperature and cockpit air temperature with the aircraft under all operating conditions. In conjunction with these checks, a carbon monoxide test was also made.

b. Equipment consisted of:

(1) Weston Aneroid Thermometer, Model 2291.

(2) Mine Safety Appliance Company *Carbon Monoxide* Tester, Category No. DS-47133.

2. Results. (See Annex A.)

3. Discussion.

a. Although reasonably high temperatures were encountered on the aircraft with doors on, windows closed and vents closed (see Annex A), it is felt that this aircraft will rarely be operated under those conditions with existing outside temperatures in the 90°F. range.

b. The recommended maximum temperatures for clothed men not especially acclimatized are as follows:

(1) Resting in still air - 88°F.

(2) Resting, with some air movement (170 FPM air velocity) - 93°F.

(3) Moderate work, still air - 78°F.

Reference: Patty, Frank A., Industrial Hygiene & Toxicology (2d ed., Vol. 1; New York: Interscience Publishers Inc., 1958).

USAARU-FO 29 July 1963
SUBJECT: Report on IH-1

c. Comparing recommended working temperatures (see above) with temperatures found in aircraft (see Annex A), a mean working temperature of 95°F. was derived. This is felt to be within limits with existing outside air temperature running in the 90°F. range.

d. Carbon monoxide was not found in this aircraft at any time.

e. The heater was checked with aircraft on the ground, engine at operating RPM, doors, vents, and windows closed. With outside air being in the 90°F. range, cockpit temperature rose to above 120°F. within 3 minutes. Heater is felt to be excellent.

/s/ J. C. Rothwell
/t/ J. C. ROTHWELL
Captain, MSC
Ass't Chief, Avn Fld Opns Div

1 Incl
as

HEATING AND VENTILATION EVALUATION OF OFF-THE-SHELF HELICOPTER TRAINERS

IH-1

Analyzed by: Captain Rothwell 14 June 1963

VENTILATION	% CO A/C	% CO Out	TEMP A/C	TEMP Out
On Ground				
Doors Off (P)	0	-	96	95
Doors On - Window Open	0	-	98	95
Doors On - Window Closed Vent Open	0	-	100	95
Doors On - Window Closed Vent Closed	0	-	104	95
Hover				
Doors Off (P)	0	-	95	94
Doors On - Window Open	0	-	98	94
Doors On - Window Closed Vent Open	0	-	103	94
Doors On - Window Closed Vent Closed	0	-	105	94
In-Flight				
Doors Off (P)	0	-	93	92
Doors On - Window Open	0	-	92	92
Doors On - Window Closed Vent Open	0	-	100	92
Doors On - Window Closed Vent Closed	0	-	102	92

	% CO		TEMP	
	A/C	Out	A/C	Out
HEATING				
On Ground, Engine at operating RPM, doors, vents, and windows closed				
Heater "Off"	0	-	98	97
Heater "On"	0	-	126	104

ANNEX A

Paragraph B

HEADQUARTERS
UNITED STATES ARMY AVIATION SCHOOL
FORT RUCKER, ALABAMA

AASDI 12 November 1963

SUBJECT: Off-the-Shelf Helicopter Mission Suitability Tests

TO: President
United States Army Aviation Test Board
Fort Rucker, Alabama

1. Inclosed corrected evaluation reports forwarded per your request.

2. This correspondence is marked "For Official Use Only" solely because of the addition of the inclosures. When the inclosures are removed, protective markings will be canceled.

FOR THE COMMANDANT:

/s/ M. J. Fayard
/t/ M. J. FAYARD
2d Lt. AGC
Asst Adjutant General

4 Incls
1. IH-1 Helicopter
2. IH-2 Helicopter
3. IH-3 Helicopter
4. IH-4 Helicopter

EVALUATION OF MISSION SUITABILITY OF THE IH-1 HELICOPTER AS CONDUCTED BY THE UNITED STATES ARMY AVIATION SCHOOL

1. Scope.

a. The IH-1 Helicopter was flown by Rotary Wing Instrument instructors from Department of Rotary Wing Training, US Army Aviation School (USAAVNS), for the purpose of evaluating its potential as a basic instrument trainer. This evaluation was conducted on the basis that the trainer is for use as a simulated instrument flight trainer only. Actual instrument flight capability was not considered. Tests were conducted in the vicinity of Fort Rucker, Alabama, performing basic maneuvers taught in the Army Helicopter Instrument Course.

b. The test aircraft and instruments furnished for evaluation were not of the configuration proposed as the final product by the manufacturer. The comments contained in this report pertain to the configuration of the test aircraft when modified by the manufacturer's technical proposal.

2. Findings.

a. Cockpit configuration.

(1) Instrument Location. Satisfactory.

(2) Instrument Suitability. Unsatisfactory. The AR-1C attitude indicator proposed incorporates an integrated attitude indicator, and turn slip indicator. The turn indicator needle does not have the capability to indicate a steep turn because of limited needle travel.

(3) Radio Control Location. Satisfactory.

(4) Switch and Auxiliary Control Location. Unsatisfactory. The collective pitch friction control was not located in a position to be easily accessible to the student pilot.

(5) Night Lighting. Undetermined. Suitability of instrument lighting could not be determined because the proposed configuration was not furnished for evaluation.

(6) Seating. Satisfactory. The left, center seating of the actual test vehicle is not considered acceptable. Seating proposed in the IH-1 is satisfactory.

(7) Storage Space. Satisfactory. Detailed location of available storage space was not included in the manufacturer's technical proposal; however, the cabin size seems large enough to accommodate satisfactory storage provisions.

(8) Instrument Training Hood. Undetermined. Drawings of the instrument training hood in the manufacturer's technical proposal appear to provide a satisfactory approach to the problem of providing an instrument training hood. A mockup of the hood was not provided, therefore, a determination of its suitability could not be made.

b. Flight Characteristics. The IH-1 Helicopter was flown at weights varying from normal operating weight to maximum certificated gross weight. Maneuvers normally required for basic rotary wing instrument training were performed with particular attention toward controllability and in-flight stability.

(1) Controllability. Unsatisfactory. Force trim (cyclic stick centering device) installed on the IH-1 required an abnormal amount of pressure to overcome force trim stick forces. In addition, no provisions were made to shut off the trim force. These two conditions are unsuitable for student training.

(2) In-flight Stability. Unsatisfactory. The IH-1 Helicopter was equipped with a stability augmentation system on the pitch and roll axes. Air stability during flight test varied from smooth to light turbulence. Pitch and roll stability was good under these conditions. Yaw instability was found to exist in light turbulence which caused a continual oscillation of the turn needle. This yaw instability was such that satisfactory partial panel flight could not be conducted. Overall stability of pitch, roll, and yaw with SAS off was unsatisfactory.

(3) Basic Maneuver Performance. The following discrepancies were noted in addition to those listed above:

(a) Large attitude changes were required for transition from a hover to cruise speed.

(b) To perform left turns, a nose low attitude indication was required to maintain level flight.

(c) To perform right turns, a nose high attitude indication was required to maintain level flight.

(4) Proposed Radio Electronic Configuration. Unsatisfactory. The IH-1 proposal indicates that the AS-580A antenna will be used for the VOR and ILS antenna. The proposed location is outside the aircraft, on the bubble top.

Previous Army Aviation School experience with this antenna, installed on helicopters, has been unsatisfactory. Tests conducted by Stanford Reasearch Institute, and the United States Army Signal Aviation Test and Support Activity, confirm the unsuitability of this type antenna.

These tests indicate that the problem of rotor modulation in helicopter installations can be solved by use of a split loop type antenna such as the AS1304 (Dorne-Margolin DMN 4-4) installed in an optimum location.

3. Conclusions.

a. The IH-1 Helicopter as proposed was found to be unsuitable in the area of mission suitability.

b. It is estimated that no major design changes in the IH-1 or associated proposal would be required to correct the deficiencies and shortcomings noted.

Paragraph C

BAAR-OT 29 July 1963

SUBJECT: USABAAR's Evaluation of IH-1 Off-the-Shelf Basic Instrument Helicopter Trainer

TO: President
US Army Aviation Test Board
ATTN: Off-the-Shelf Project Officer
Fort Rucker, Alabama

1. The following is USABAAR's evaluation of the IH-1 entry for the off-the-shelf instrument helicopter trainer competition. The evaluation considered the categories of aviation safety and accident prevention in three primary categories. In each of these categories, USABAAR found the aircraft to be acceptable for its intended mission. However, there are certain deficiencies which will detract from its mission capability and should be considered by those responsible for selecting the winner of the competition. Categories considered are:

a. Operational Safety - This category considers those features of the aircraft and its operating characteristics that are considered to be conducive to accident causation and which may detract from the operator's ability to maintain safe flight at all times.

b. Maintenance Safety - This category considers maintenance design features of the aircraft contributing to accident causation. It includes those features of "Murphy's Law," ease of inspection, accessibility for component replacement, the preflight inspections imposed on the operator, etc.

c. Crashworthiness - This category considers design features of the aircraft that, in the event of a crash, provide protection to the occupants from injury. It also includes features of crash-fire worthiness.

BAAR-OT 29 July 1963
SUBJECT: USABAAR's Evaluation of IH-1 Off-the-Shelf Basic Instrument Helicopter Trainer

2. Evaluation comments are as follows:

a. Operational Safety -

(1) There are no provisions for a light to illuminate approach plate.

(2) Navigation lighting creates slight detracting reflections on the bubble during night operations.

(3) The short skid shoe installation exposes skids to catching on ground objects. Installation of full length skid shoes is required to preclude snagging ground objects.

b. Maintenance Safety

Magnetic chip detector - Install magnetic chip detectors and cockpit warning lights of the continuous readout type in the transmission and engine oil sumps.

c. Crashworthiness

(1) Cockpit lacks structural members which would protect crew members in the event of roll-over or landing hard at other than a level attitude.

(2) No description of the materials to be used in the construction of the "hood" was mentioned. The material could easily become a missile or injury-producing factor in the event of a hard landing or crash (dependent upon composition and means of tiedown).

3. If any of the above noted discrepancies are eliminated due to manufacturer's proposal, they are of no consequence.

4. The following features are recognized as desirable and considered worthy of mention:

a. The basic IH-1 airframe construction has an excellent post crash-fire record in the accident experiences on file at USABAAR.

BAAR-OT 29 July 1963

SUBJECT: USABAAR's Evaluation of IH-1 Off-the-Shelf Basic Instrument Helicopter Trainer

b. Controllability and stability during flight is excellent.

/s/ Robert M. Hamilton
/t/ ROBERT M. HAMILTON
Colonel, Infantry
Director, USABAAR

Paragraph D

US ARMY AVIATION HUMAN RESEARCH UNIT
Fort Rucker, Alabama

11 July 1963

Human Factors Evaluation of IH-1(5) (inst.) and
IH-1(3) (inst.) Aircraft

1. Summary

1.1 The arrangement of the instrument panel is regarded as less than optimum from the instructor's standpoint. The 2 x 1 seating arrangement of the IH-1(5) is not considered desirable for the basic instrument training mission unless achieved at very minor additional initial and operational costs. Sideward visibility is too restricted by the wide door trim.

2. Detailed Considerations

The aircraft were regarded as acceptable from the human factors standpoint with the exception of the considerations listed below.

2.1 The rear seat of the IH-1(5) does not have sufficient leg room to accommodate an observer for a significant period of time without considerable discomfort. Exchange between the student and observer seats while airborne is not considered practical from the safety standpoint.

2.1.1 No significant value to basic instrument training is expected to result from observation from the rear seat.

2.2 It appears that a number of indicators are unnecessarily placed on the upper instrument console. Without these the basic instrument group could be moved closer to the instructor. This is considered desirable, since it will provide a less oblique view of the basic instrument group by the instructor. It should also reduce the clutter of the basic panel.

2.2.1 Figure 1 indicates a panel that, without consultation with instrumentation engineers, is considered preferable.

2.2.1.1 In this proposed location, it would be desirable to provide a lock for the ignition switch. It definitely should not be located adjacent to the AN/ARC45 control.

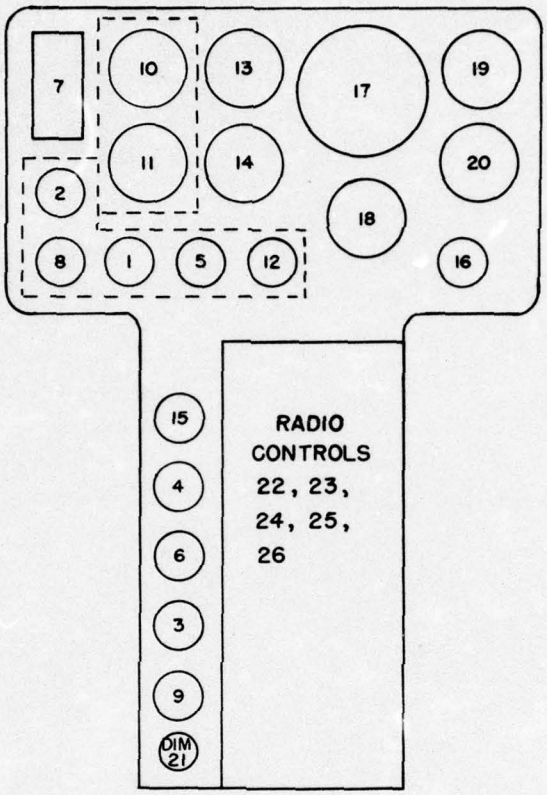
2.2.1.2 The indicators moved to the lower panel are mainly those for monitoring the electrical system, for which primary monitoring is served by the generator warning light. The engine oil pressure indicator could have been placed on the lower panel since it is primarily monitored by its warning light. Retention with the other engine condition indicators was considered desirable however.

2.3 The masking of general sideward visibility by the wide door trim of the IH-1(5) is considered undesirable.

/s/Robert H. Wright, Ph.D.
/t/ROBERT H. WRIGHT, Ph.D.
Research Scientist

and

/s/H. Alton Boyd, Jr.
/t/ H. ALTON BOYD, JR.
Research Associate



1. Cylinder Head Temperature Indicator 2"
2. Oil Temperature Indicator 2"
3. AC Voltmeter 2"
4. DC Volt ammeter 2"
5. Carburetor Temperature Indicator 2"
6. Ignition Switch
7. Warning Lights
   Hydraulic Pressure
   Engine Oil Pressure
   Transmission Oil Pressure
   20 Min. Fuel
   Generator
8. Oil Pressure Indicator 2"
9. Frequency Meter 2"
10. Dual Tach 3"
11. Manifold Pressure Indicator 3"
12. Fuel Pressure Indicator 2"
13. Air Speed Indicator 3"
14. VOR Glide Slope Indicator and Course Selector 3"
15. Fuel Quantity Indicator 2"
16. Elapsed Time Clock 2"
17. Attitude Indicator 5"
18. Heading Indicator 3"
19. Altimeter 3"
20. Rate of Climb Indicator 3"
21. Instrument Lights Switch
22. UHF Control Panel (AN/ARC45)
23. VOR Control Panel (AN/ARN30E)
24. ADF Control Panel (AN/ARN59)
25. Interphone Panel
26. Interphone Panel

Figure 1

UNIT B - COMPANY B MODEL IH-2

SECTION ONE

USAAVNTBD REPORT

A. Description of Materiel.

1. The IH-2 is a single-engine, three-place, side-by-side, two-bladed single-main-rotor- and tail-rotor-type helicopter. Power is supplied by a TVO-435 vertically-mounted six-cylinder, opposed-type air-cooled supercharged engine, which provides maximum rated power of 270 brake horsepower at 3200 r.p.m. from sea level to 14,000 feet. Engine power is transmitted to the rotors through a double planetary reduction transmission. The main rotor mast assembly is set into the transmission, which is bolted to the engine, making the complete assembly one rigid unit. Takeoff shaft connections extend from the transmission to drive the tail (antitorque) rotor.

2. Flight controls consist of a cyclic stick, collective pitch stick, and antitorque pedals. The collective and cyclic controls are power boosted with hydraulic cylinders which have a lock and load limiting feature. Adjustable friction devices are provided for the cyclic and collective pitch.

3. The main rotor system consists of two-bladed teetering rotor, blade grips, hub, and stabilizer bar. The all-metal blades which have ten-pound weights installed in each tip provide 50-percent higher rotor inertia than previous models. A two-bladed, all-metal antitorque tail rotor mounted on a delta hinge provides a means for directional control.

4. The helicopter center body section and tail boom are of a welded tubular steel construction. The cabin enclosure consists of a transparent, tinted, plexiglas bubble. The internal cabin is 5 feet wide. This width allows sufficient space for the three-place seating. The cabin door incorporates sliding windows with air deflectors for improved ventilation. Additional air circulation is provided by individually positioned, soft rubber fans located on the left and right side of the center pedestal.

5. General dimensions of the helicopter submitted for test are listed below:

a.	Overall height	9 feet 4 inches
b.	Overall length (main rotor tip to tail rotor tip)	43 feet 3 inches
c.	Main rotor diameter	37 feet 2 inches
d.	Fuselage width	5 feet 5 inches
e.	Skid gear tread	7 feet 6 inches

B. Scope of Test. The test was conducted in the vicinity of Fort Rucker, Alabama, by USAAVNTBD project officers and USAAVNS rotary-wing instrument instructor personnel. The test consisted of three phases: a 25-flying-hour evaluation; a thorough study of the manufacturer's technical proposals which described changes to be made to configure the test helicopter to meet the stated requirements; and a comparison of the helicopter with the Model Specification and the Statement of Requirement. In addition, the US Army Board for Aviation Accident Research (USABAAR) evaluated the aviation safety aspects; the US Army Aviation Human Research Unit (USAHUMRU) evaluated the test helicopter from the human factor aspects; and the US Army Aeromedical Research Unit (USAARU) evaluated noise level, internal lighting, and heating and ventilation. Complete reports as received from each of these units are contained in section two.

C. Tests.

1. Evaluation of Physical and Flight Characteristics, Performance, and Maintenance.

a. Physical Characteristics.

(1) Basic Weight. The basic weight was determined by weighing the helicopter as delivered with oil and trapped fuel. To this weight (1900 pounds), the weight of electronic and auxiliary equipment required for Army use (328 pounds) was added, and the weight of currently-installed equipment not required for Army use (100 pounds) was subtracted, resulting in a total basic weight of 2128 pounds. The

estimated mission operating weight was then computed by adding to the estimated basic weight the weight of fuel (342 pounds) and 450 pounds (instructor, student, and instructional equipment). Details follow:

EMPTY WEIGHT as weighed (less ground-handling wheels)	1900 lb.
Required equipment to be added:	
A-13A Clock	.5
C-6X Radio magnetic indicator	3.0
DG401 gyro/amplifier	3.6
Sperry flux valve	1.5
MS28049-1 vertical speed indicator	1.5
AR-1C attitude indicator	8.5
Sperry vertical gyro	3.5
Sperry rate gyro	1.2
Wire and hardware	3.7
Inverters (2)	14.0
MA-7 battery	34.0
100-amp. generator kit	38.0
Wiring and supports	3.0
AN/ARC-45 (UHF)	26.0
ARC Type 15F (Omni)	28.0
ARC Type 21 (ADF)	25.0

R-844 marker beacon/ glide slope	11.0	
C-1611/AIC intercom (2)	4.0	
Wiring and supports	25.0	
Military upholstery	15.0	
Shoulder harness and inertia reel (2)	9.0	
First aid kit and fire extinguisher	10.0	
Instrument panel addition	6.0	
Student hood	10.0	
30,000-B.t.u. combustion heater	43.0	
TOTAL ADDED	328.0 lb.	+328 lb.
		2228 lb.
Installed equipment to be removed:		
AN3154 battery	34	
50-amp. generator	20	
Commercial upholstery	31	
Commercial radio	15	
TOTAL SUBTRACTED	100 lb.	-100 lb.
BASIC WEIGHT (estimated)		2128 lb.
Main fuel (57 gal.)	342	

Instructor pilot, student, and instructional equipment	450	
	792 lb.	792 lb.
MISSION OPERATING WEIGHT (estimated)		*2920 lb.
REMAINING AVAILABLE PAYLOAD		30 lb.
MAXIMUM CERTIFICATED GROSS WEIGHT		2950 lb.

*Includes approximately 54 pounds of fuel more than the required quantity for an endurance of 2.5 hours.

(2) Ground-Handling Characteristics. Ground-handling characteristics were satisfactory, utilizing the removable ground-handling wheels provided with the helicopter.

(3) Adequacy of the Cockpit Configuration and Arrangement. The cockpit configuration and arrangement of the test helicopter were evaluated except for those items changed in the manufacturer's technical proposal. The cockpit configuration and arrangement were satisfactory except for the following:

(a) The location of the instructor pilot's magnetic compass was undesirable in that the instructor was required to look away from the instrument panel to read the compass. The compass was located on the left door frame at the top door hinge.

(b) The location of the hydraulic boost by-pass switch required the pilot to release the collective control to turn off the system in the event of malfunction.

(c) Installed seat belts did not meet military specifications.

(4) Noise Level. Overall internal and external sound pressure levels were acceptable. However, many of the internal measurements exceeded the military specification for acoustical noise levels in Army aircraft (paragraph A, section two).

(5) Suitability of External Lighting. External lighting was satisfactory and met Model Specification requirements with the exception of the landing light ON-OFF switch located on the instructor's collective pitch stick.

(6) In-Flight Visibility. Visibility from the instructor-pilot seat was satisfactory except for the obstruction of the oversize fuel cells to the right rear. The top door frame on the instructor's side also blocked visibility to the left side.

(7) Ventilation. Ventilation was adequate.

(8) Suitability for Hoisting, Jacking, and Mooring. The helicopter was equipped with suitable hoisting and jacking points and had suitable locations on the structure for attachment of mooring lines.

(9) Suitability of External Power Receptacle. The helicopter was equipped with an external power receptacle compatible with the Army's APU's.

(10) Center-of-Gravity Travel. The CG of the helicopter remained within limits without addition of ballast or relocation of components regardless of changes in loading of the helicopter with respect to fuel, instructor pilot, and student.

b. Flight Characteristics. The helicopter was flown at weights varying from mission operating weight (2920 pounds) to maximum certificated gross weight (2950 pounds). Maneuvers normally required of a rotary-wing basic instrument trainer were performed with particular attention toward controllability and in-flight stability.

(1) Controllability.

(a) Aircraft control response was considered excellent.

(b) Flight characteristics were satisfactory with the hydraulic boost turned off. Hover flight in this condition could be performed satisfactorily. In cruise flight, collective and cyclic forces were acceptable with hydraulic boost turned off. Autorotations with hydraulic boost turned off were made safely.

(c) Large changes in pitch attitude were required for transition from a hover to a cruise of 70 knots. These attitude changes are undesirable for student instrument training but are considered normal for a helicopter of this size.

(2) In-Flight Stability. Stability of the IH-2 was evaluated in pitch, roll, and yaw. Only smooth-to-lightly-turbulent air was encountered during the flight test period. Performance of the aircraft indicated that satisfactory stability around all axes could be anticipated. However, a final determination of stability could not be made because flight attitude instruments were not furnished.

(3) Autorotational Characteristics. The longer rotor blades with the additional 10-pound tip weights made autorotational characteristics well above average at all operating weights. Entry into autorotation could be made with a minimum loss in rotor r.p.m. which is characteristic of a high inertia rotor system.

c. Performance. The helicopter was flown at both mission operating weight (2920 pounds) and maximum certificated gross weight (2950 pounds) to determine whether it met the performance criteria as specified in the Model Specification. The following were determined:

(1) Maximum cruise airspeed (true) at 5000 feet m.s.l. (standard conditions) was 70 knots.

(2) Endurance at 5000 feet m.s.l. (standard conditions) at 70 knots (true airspeed) was 3 hours.

d. Maintenance.

(1) During the evaluation, the helicopter was maintained by the manufacturer's representative with military personnel provided for servicing, general assistance, and maintenance of records.

(2) No provisions were made for quick-disconnect of the battery.

(3) Engine operation on standard Army fuel (115/145 octane) and lubricants was satisfactory.

(4) The helicopter was easy to service and maintain. All major components were readily accessible; however, no replacements were required during the evaluation.

(5) Tools and ground support equipment normally found at the organizational level were adequate for organizational maintenance. Special tools are required for higher echelons of maintenance.

2. Evaluation of Manufacturer's Technical Proposal. A thorough study was made of the manufacturer's technical proposal which described changes to reconfigure the test helicopter to meet the stated requirements. The following were determined:

a. Adequacy of the Cockpit Configuration and Arrangement as Proposed.

(1) Proposed location of the standby magnetic compass for the student pilot was unsatisfactory. The technical proposal indicates that the magnetic compass will be installed on the right door frame at the top door hinge. This location, for the student pilot, is approximately 18 inches to the right of the instrument panel, which precludes an easy crosscheck.

(2) The mixture and carburetor heat control quadrant, with the instrument training hood installed, would not be readily accessible to the student pilot.

(3) The location of the map light for the student pilot was not satisfactory.

(4) No provisions were made to relocate the following items from their present location to a similar position on the right side of the cockpit.

(a) Friction control devices for throttle, cyclic, and collective pitch.

(b) Starter and landing light controls.

(c) Main fuel shut-off valve.

(5) Seat belts and shoulder harnesses with inertia reels for all occupants were included in the technical proposal; however, suitability could not be determined.

(6) Floor-mounted and cyclic-control-mounted radio-interphone switches were provided for both student pilot and instructor.

(7) A mockup of the proposed instrument panel, and instrument training hood was provided. This mockup could not be placed exactly in the position of a production panel because of the instrument panel in the test aircraft. The hood appears to be satisfactory, but a final determination of suitability could not be made. Additional consideration should be given to provide a shield for the lower part of the pilot's door to prevent possible distraction. The instrument training hood appeared to provide maximum visibility with a minimum of obstruction to the instructor pilot's outside vision. Material proposed and method of installation of instrument training hood appeared to be satisfactory; however, it would be more desirable if the panels installed on the student's side of the instrument console could be collapsed for increased student visibility in the event of an emergency.

(8) Detailed location of available storage space was not included in the manufacturer's technical proposal; however, the cockpit appeared large enough for adequate storage of instructional material.

b. Suitability of Internal Lighting. The cockpit instrument panel illumination met model specifications (paragraph A, section two).

c. Heater. A heater was not installed on the test helicopter, but a 30,000 B.t.u. heater was proposed.

d. Instrumentation and Panel Arrangement Proposal.

(1) The manufacturer's proposal for a production panel configuration and instrument arrangement was satisfactory except for the turn-and-slip indicator.* The use of an attitude indicator (AR-1C) with an integral horizontal bar turn-and-slip indicator which was proposed is considered unsuitable. If operating on partial panel,

*The manufacturer provided a temporary installation of the proposed five-inch attitude indicator which included a four-minute turn-and-slip indicator. Considerable difficulty was experienced interpreting rate of turn because of the helicopter yaw instability which resulted in a rapid oscillation of the turn indicator. This problem was partially alleviated by the installation of an oscillation damper that slowed the needle rate on the turn indicator. The manufacturer has revised their proposal to include a rate damper in production aircraft.

no reference is available to determine the rate of turn when greater than standard rate, because the maximum travel of the turn indicator is limited to turns slightly greater than standard rate.

(2) A manifold pressure indicator and engine tachometer were provided.

(3) In the technical proposal, the instrument panel was front-mounted and arranged in the standard "T" except for the location of VOR course indicator which did not conform to the position indicated in appendix II of the Model Specification. However, the proposed location is considered satisfactory.

(4) All instruments required by the Model Specification under the navigational group were provided in the technical proposal.

(5) Switches and auxiliary controls necessary for flight and navigation as shown in the technical proposal were accessible and within reach of the student pilot and instructor.

(6) The radio control panel as shown in technical proposal was accessible, both visually and physically, to the student pilot and instructor pilot.

(7) No information was available to determine suitability of the proposed SPC-1 heading reference.

e. Mission Suitability. The IH-2 as proposed was unsuitable in the area of mission suitability. (See paragraph B, section two, for the complete report from the USAAVNS.)

f. Electronic Configuration. The helicopter provided for evaluation was not equipped with the electronic equipment specified in appendix I of the Model Specification. The manufacturer's proposal submitted with the helicopter specified the location and installation of all electronic components. The proposed electronic configuration was satisfactory with exception of the inverters included in the technical proposal, which did not conform to the appendix I, of the Model Specification. Two SI-121 Static Inverters were proposed in lieu of inverters listed. No information was available on the reliability or durability of the proposed inverters.

g. Aviation Safety. The evaluation considered the categories of operational safety, maintenance safety, and crashworthiness. In the categories of operational safety and maintenance safety, USABAAR found the aircraft to be acceptable for its intended mission. The IH-2 was found to be unacceptable in the crashworthiness category. The post-crash fire potential of this aircraft appears to be even greater than that of other twin saddle fuel tank models (see paragraph C, section two, for the complete report).

h. Human Factors. With regard to human factors considerations in the crew area, the IH-2 is acceptable for use as a two-place basic instrument trainer, with the following exceptions: The ignition switch is located so that it is susceptible to inadvertent activation, visibility on the right side is restricted, warning lights are not utilized on the instrument panel, the seats are not adjustable, and the student cannot reach the carburetor air and mixture controls. For details, see paragraph D, section two.

3. Comparison with Model Specification and Statement of Requirement. The extent to which the IH-2 met the requirements of the Model Specification and Statement of Requirement was determined by consideration of the characteristics of the helicopter as tested and an evaluation of the manufacturer's technical proposal.

a. Comparison with Model Specification as Amended.

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
1.	SCOPE.		
1.1	Scope. This detail specification covers the essential requirements for the design of a single engine Helicopter Basic Instrument Trainer capable of performing the mission specified in 1.2		
1.1.1	Designation and General Description.		

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
	Army Model Designation - Helicopter Basic Instrument Trainer (model number not yet assigned)		
	Number of crew - 1 pilot	Yes	
	Number of passengers - 1 student	Yes	
	Crew and passenger seating arrangement - side by side (instructor pilot on the left)	Yes	
	Flight controls - dual	Yes	
	Main rotor system - single	Yes	
1.2	Mission. The primary Army mission for which this helicopter will be employed is training of military pilots in helicopter instrument flying. Training will be accomplished under simulated instrument flight conditions.	No	See USAAVNS report for complete details (paragraph B, section two).
1.3	Federal Aviation Agency Certification. The helicopter will have a part 6 standard airworthiness certificate issued by the Federal Aviation Agency.	Yes	
1.4	Performance Information. Those items of performance stated as requirements	Not required	

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
	herein which are not included in the FAA approved flight manual are subject to verification by the US Army.		
2.	APPLICABLE DOCUMENTS.		
2.1	The documents applicable to this specification are those necessary to fulfill the requirements of paragraph 1.3, Federal Aviation Agency Certification.	Yes	
3.	REQUIREMENTS.		
3.1	Basic Weight. The basic weight of the helicopter will include all required installed equipment including the avionics as stated in paragraph 3.7.1, 3.8.1.1, 3.8.1.2, and 3.10.1.	Yes	
3.2	Center-of-Gravity Travel. Addition, removal, or relocation of ballast or aircraft components will not be necessary in order to maintain the CG within CG limits due to changes in loading of the helicopter with respect to fuel, pilot and student.	Yes	
3.3	Required Performance.		

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
3.3.1	NASA Standard Day Conditions (at certificated gross weight).		
	Cruise speed (minimum) - 70 knots at 5000 feet m.s.l.	Yes	Using maximum allowable continuous power, maximum cruise speed obtained was 70 knots.
	Endurance (minimum) - 2 1/2 hours at 70 knots cruise speed at 5000 feet m.s.l.	Yes	Helicopter was capable of 3 hours endurance.
3.3.2	Useful Load. The useful load of the helicopter will be sufficient for 450 pounds in addition to fuel and oil necessary to accomplish the endurance performance mission specified in paragraph 3.3.1.	Yes	Remaining available payload was 30 pounds with full fuel.
3.4	Aircraft Structure.		
3.4.1	Landing Gear.		
3.4.1.1	Type Landing Gear. Type of landing gear is optional.	Yes	Skid-type was utilized.
3.4.1.2	Ground Handling. Ground-handling wheels are required. Weight of the ground-handling wheels will not be included in the weight empty if they are detachable.	Yes	

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
3.4.1.3	Hoisting, Jacking, and Mooring. Provisions will be made for hoisting, jacking, and mooring.	Yes*	
3.5	Operating Environment.		
3.5.1	Aircraft Operation. The aircraft will be capable of operating in temperatures from 0°F. to +100°F.	Undetermined	Manufacturer's technical proposal states that the helicopter is capable of operation in temperatures from 0°F. to +100°F. Temperatures during test period varied from +75°F. to +95°F. No difficulties were noted.
3.5.2	Cabin Heating. The aircraft will have a heating system which provides a minimum of 50°F. cabin temperature, with 0°F. outside air temperature. This condition need only be satisfied with the engine operating.	Yes*	A 30,000-B.t.u.-capacity heater was included in technical proposal.
3.5.3	Defrosters. This aircraft will include defrosters on both sides of the windshield.	Yes*	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
3.6	Fuel and Lubricants. The engine will operate on such fuel and lubricants which are now established as standard by the US Army. (Reference: MIL-G-5572C dated 12 July 1960, MIL-L-22851 dated 30 July 1961, and MIL-L-6082C dated 18 May 1961.)	Yes	The IH-2 was operated on 115/145 octane gasoline and Army non-detergent oil during conduct of the test.
3.7	Instruments and Navigation Equipment. Flight instruments and lights for day and night VFR flight conditions will be furnished and installed by the contractor. Standard "T" arrangement, front mounted panel, is required. Instrument panel will be arranged to permit unobstructed vision of instruments by the instructor pilot and student pilot.	Yes*	
3.7.1	Navigational Group. The following instruments are required:		
	Attitude indicator - five-inch, non-precessing, non-tumbling type.	Yes*	The indicator must have adequate pitch and roll adjustment.
	Heading indicator - three-inch, radio magnetic indicator RMI type.	Yes*	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
	Vertical-speed indicator - instantaneous type.	Yes*	
	Altimeter - sensitive, barometric	Yes	
	Airspeed indicator - (indicated in knots)	Yes*	
	Turn-and-slip indicator - four-minute turn needle	Yes*	Incorporated in AR-1C attitude indicator but considered unsuitable.
	Magnetic compass - located for easy reference by student pilot and instructor pilot.	No*	Proposed location of student pilot's magnetic compass was unsatisfactory.
	Clock - elapsed time	Yes*	
3.7.2	Power Group.		
	a. For reciprocating engine: a manifold pressure indicator and engine/main rotor tachometer are required.	Yes	
	b. For turbine engine: a gas producer indicator, torquemeter, and engine/main rotor tachometer are required.	N/A	
3.8	Electrical.		

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
3.8.1	Lighting.		
3.8.1.1	Anti-Collision Light. The aircraft will have an anti-collision light. The light will be located to prevent reflection into the cockpit.	Yes	
3.8.1.2	Landing Light(s). The aircraft will be equipped with landing lights which will be adjustable. The landing light switch will be located on the pilot's cyclic or collective controls.	No	Landing light switch is located on instructor's collective pitch stick. Landing light was manually adjustable on the ground.
3.8.2	Power Receptacle. The aircraft will be equipped with an external power receptacle of an AN or AMS standard design.	Yes	
3.8.3	Switches and Auxiliary Controls. All switches and auxiliary controls necessary for flight and navigation will be accessible and within reach of the student pilot and the instructor pilot. Switches and controls shall be operable in flight by personnel wearing winter flight clothing. Accessible floor mounted and cyclic	No*	Mixture and carburetor heat control quadrant will not be readily accessible to student pilot with instrument training hood installed.

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
	control mounted radio-interphone switches will be provided for both student pilot and instructor.		
3.9	Other Equipment and Requirements.		
3.9.1	Instrument Training Hood. A permanent type hooded device which will allow the student to observe the instruments and not allow observance outside the aircraft will be provided. This device will not obstruct the vision of the instructor pilot.	Undetermined	It would be more desirable if the panels installed on the student's side of the instrument console could be collapsed for increased student visibility in the event of an emergency. See paragraph B, section two, for complete details.
3.9.2	Safety Equipment. Seat belt and shoulder harness for all occupants will be provided.	Yes*	Shoulder harness with inertia reels indicated in technical proposal.
3.9.3	Control Pedals. Adjustable control pedals will be provided.	Yes	
3.9.4	Storage Space. Storage space for navigational equipment such as maps, charts, computers, and	Yes	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
	navigational kit (TM 11-2557) will be provided.		
3.10	Avionics.		
3.10.1	Electronic Equipment. The aircraft will be equipped with electronic equipment as indicated in appendix I.	No*	SI-121 static inverters were proposed.
3.10.2	Radio Control Panel. Must be accessible, both visually and physically, to the student pilot and the instructor pilot. Overhead location is not acceptable.	Yes*	
	APPENDIX I.		
	Communications.		
	UHF - AN/ARC-45, 1 each	Yes*	
	ICS - C1611, 2 each	Yes*	
	Navigation.		
	VOR - Aircraft Radio Corp. Type 15F, 1 each	Yes*	
	RMI Converter - ARC Type B-18A, 1 each	Yes*	
	ADF - Aircraft Radio Corp. Type 21A, 1 each	Yes*	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-2 Meets Spec.	Remarks
	MB/GS - Collins Babcock, 1 each. (Marker Beacon Glide Slope Receiver to be commercial counterpart of R-844, if available.)	Yes*	
	Heading reference, 1 each (Contractor selected and furnished systems having capabilities equal to or superior to Army Standard J-2 compass (commercial C-4). Equipment will be furnished with C-6H indicator. The selected system shall be qualified to FAA Technical Standard Order C6C and shall bear TSO Type A certification decals.)	Undetermined*	No information was available to determine suitability of the proposed SPC-1 heading reference.
	Instrumentation.		
	RMI - Sperry C-6H, 1 each	Yes	
	Miscellaneous.		
	Antenna - AT-450/ARC, 1 each	Yes*	
	Battery, Sonotone MA-7, 1 each	Yes*	
	Inverter - Leland MG-E-93-200 or Bendix 328-172-1, 2 each	No	SI-121 static inverters were proposed.

*Not tested; included in technical proposal.

b. Comparison with Statement of Requirement. A comparison with the Statement of Requirement (reference 3), excluding those requirements covered by the Model Specification, follows:

Performance. Unless otherwise specified, the following should be attained at NASA standard conditions with an instructor pilot, one student pilot, and fuel for 2.5 hours endurance at normal cruise.

Requirement	IH-2 Meets Requirement	Remarks
Cruise airspeed (standard day) 5000 feet m.s.l. (knots)		
Essential - 70	Yes	70 knots maximum obtainable with maximum continuous power.
Desired - 90	No	
Endurance (at cruise airspeed) 5000 feet m.s.l., no reserve (hours).		
Essential - 2.5	Yes	Capable of 3 hours' endurance.
Desired - 3.5	No	
Stability - Adequate yaw, roll, and pitch stability in light to moderate turbulence.	Undetermined	See USAAVNS report for details (paragraph B, section two).
Cabin Arrangement		
Windshields constructed of material highly resistant to scratching.	Yes	Latest state-of-the-art material is used for bubble. No scratches were acquired during conduct of evaluation.
Warning lights on panel to include fuel, oil, hydraulic and electrical systems (desired).	No	

Requirement	IH-2 Meets Requirement	Remarks
Earphone and microphone jacks and cords compatible with APH-5 helmet for all occupants.	Yes*	
Personnel Considerations.		
No new personnel skills will be required.	Yes	Because of the similarity to other helicopters in the Army, no new personnel skills will be required.
Training Considerations.		
No new training requirements will be generated.	Yes	No additional service schools will be required.
No supporting training devices other than those on hand at the US Army Training Base are required.	Yes	

D. Deficiencies and Shortcomings.

1. The following deficiencies were noted during conduct of the evaluation:

Deficiency	Suggested Corrective Action
a. Location of magnetic compass was unsatisfactory.	Centrally relocate at center top of instrument panel for easy reference by both student and instructor.

*Not tested; included in technical proposal.

Deficiency	Suggested Corrective Action
b. Landing light switch was not located on student's cyclic or collective controls.	Relocate landing light switch to student's collective pitch control.
c. SI-121 static inverters (not listed in Model Specification) were proposed.	Provide inverters listed in appendix I of Model Specification.
d. Turn-and-slip indicator incorporated in AR-1C attitude indicator was unsuitable.	Install separate standard 3-inch turn-and-slip indicator (4-min.) left of the VOR glide-slope indicator.
e. Secondary cockpit controls were not arranged for access by the student.	Rearrange controls to same positions on student's side.
f. Aircraft was not crashworthy because of its post-crash fire potential.	Reduce post-crash fire potential.
g. The location of the map light was not satisfactory.	Provide two standard detachable map lights and locate above and to the left of the instructor and student.
h. Mixture and carburetor heat control quadrant was not readily accessible to student pilot.	Modify glare shield to encompass control quadrant.

2. The following shortcomings were noted during conduct of the evaluation:

Shortcoming	Suggested Corrective Action
a. Ignition switch was located so that it was susceptible to accidental activation.	Provide protective shield for ignition switch.
b. No provisions were made for quick-disconnect of the battery.	Provide for quick-disconnect of the battery.

Shortcoming	Suggested Corrective Action
c. Location of exhaust gas outlet and supercharger housing creates a danger of fire when operating in grassy areas.	Reduce danger of fire from exhaust for outlet and supercharger housing.
d. Fuel-selector valve control connection located in tail boom behind the engine was susceptible to damage.	Relocate fuel-selector valve control connection to a position less susceptible to damage.
e. Fuel, oil, hydraulic, and electrical system warning lights were not utilized on instrument panel.	Provide warning lights.
f. Magnetic chip detectors were not installed in the engine and transmission oil sumps.	Provide magnetic chip detectors.

SECTION TWO

Reports from Other Agencies on the IH-2

PARAGRAPH A

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama 36362

USAARU-FO 29 July 1963

NOISE EVALUATION OF THE IH-2

1. Methods and Equipment.

a. Due to the number of aircraft to be tested and the short time available for testing, the noise analysis was limited to the following:

"A" 24-55db: sound level for speech interference.

"B" 55-85 db: sound level for noise survey.

"C" 85-140 db: sound pressure level, over-all frequency response.

b. A Sound-Level-Meter, General Radio, type 1551-C, was used for the noise measurement.

c. The test area, located at County Line Strip, is a pre-marked circle with a radius of 50 feet divided into 30° segments.

2. Results. (See Annex A)

3. Discussion.

	Doors On	Doors Off	MIL-A-8806
Normal cruise	103	113	106
Maximum cruise	104	116	113

a. Operation of this helicopter at maximum cruise with the doors off produced an excessive sound pressure level of 116 decibels. Variation of airspeed and relative wind direction demonstrated the fact that straight and level flight at speeds of 75 to 85 mph produced sufficient wind buffeting in the cockpit to record a decibel range of 116 to 120, which exceeds Table 1 MIL-A-8806.

b. Normal cruise with the doors off produced 113 decibels which exceeds Table IV MIL-A-8806.

c. There are no military specifications for external noise. Raw data is included for comparison purposes only.

4. Summary. Improvements should be made to reduce noise levels to meet military specifications (MIL-A-8806).

1 Incl
as

/s/ William C. Thrasher
/t/ WILLIAM C. THRASHER
2/Lt, MSC
Ass't Chief, Avn Fld Opns Div

NOISE LEVEL MEASUREMENTS-OCTAVE BAND ANALYSIS

DATA COLLECTION SHEET

Analyzed by Lt Thrasher Date 16 July 1963

IH-2

DOORS-ON	A	B	C	Center	Instructor	Air Speed	Mani-fold	RPM	Radius
Ground idle	85	92	97		x		12.5"	1700	
Ground high power	92	95	100		x		24"	3200	
Hover	93	97	101		x		28"	3200	
Normal cruise	94	98	103		x	70	26"	3100	
Maximum cruise	94	97	104		x	80	27.2"	3200	
DOORS-OFF									
Ground idle	87	97	101		x		12.5"	1700	
Ground high power	97	104	109		x		24"	3200	
Hover	99	104	107		x		28"	3200	
Normal cruise	98	106	113		x	70	26"	3100	
Maximum cruise	99	107	116		x	80	27.2"	3200	
EXT HIGH POWER							24"	3200	50'
0	90	97	101	210°	90	103	106		
30	92	98	102	240°	96	101	105		
60	95	100	102	270°	93	99	103		
90	95	102	106	300°	91	99	101		
120	97	103	106	330°	90	97	101		
150	97	103	107						
180	95	102	105						
HOVER							28"	3200	50'
0	91	98	101	210°	101	104	108		
30	91	96	102	240°	98	102	106		
60	94	100	104	270°	94	99	104		
90	96	100	105	300°	95	98	103		
120	97	104	107	330°	92	98	101		
150	101	105	108						
180	99	103	107						

Annex A

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama 36362

USAARU-FO

29 July 1963

LIGHT EVALUATION OF THE IH-2

1. Methods and Equipment.

The evaluation consisted of in-flight analysis of the aircraft's lighting system under night conditions. Criteria for this evaluation were derived from U. S. Navy Specifications governing cockpit and instrument panel illumination modified to meet Army requirements.

2. Results. (See Annex A)

3. Discussion.

a. Instrument panel light reflections on the bubble are apparent when the lights are adjusted to the highest setting. With proper adjustment, all reflections from the instrument panel are eliminated.

b. During the twilight hours reflections from the light colored interior accessories were noted on the lower portions of the bubble.

c. The intensity of the auxiliary light or map light may be adjusted by rheostat and a lens selector gives the light the capability of white or standard red illumination.

4. Summary. The cockpit and instrument panel illumination of this aircraft is adequate for an instrument trainer capable of performing night training missions.

1 Incl
as

/s/ William C. Thrasher
/t/ WILLIAM C. THRASHER
2/Lt., MSC
Ass't Chief, Avn Fld Opns Div

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama 36362

COCKPIT LIGHT STUDY
IH-2

1. Are all instruments adequately illuminated? Yes

2. Are they illuminated uniformly? Yes Is there sufficient intensity? Yes

3. Is illumination controllable to very low intensities? Yes (Rheostat)

4. Are markings of instruments readable? Yes

5. Are all controls, instructions, and nameplates adequately illuminated? Yes

6. Are they illuminated uniformly? Yes Is there sufficient intensity? Yes

7. Is illumination controllable to very low intensities? Yes

8. Are markings on controls, instructions and nameplates readable? Yes

9. Is the intensity of lighting for some instruments and controls controlled separately? Yes

10. Is an auxiliary light provided? Yes Is light standard red? Yes

11. Is the power source independent of normal lighting circuit? Yes

12. Are there any sources of light which give other than standard red light? Yes (Note para 3c)

13. Are there any reflections in the windshield, windows, canopy or other reflecting surfaces which interfere with visibility inside or outside the cockpit? Yes (see para 3a & b)

14. Is there light leakage into the cockpit from other compartments? N/A

15. Are spare lamps provided in sufficient quantity and easily accessible? N/A

Annex A

16. Are all instruments, instructions, nameplates, and control markings readable in daylight? Yes

17. Can warning and caution lights be dimmed sufficiently for night operations? Yes

18. Are warning and caution lights of sufficient intensity for daylight use? Yes

19. Are warning and caution lights on the main dimming circuit? No

20. Is lighting provided in accordance with the aircraft detail specification? N/A

21. Is the light adequate for reading? Yes

22. Does the light cause glare to cockpit? Yes

23. Is there adequate general illumination for the compartment? Yes

24. Do any of the exterior lights provide glare in the cockpit? No

25. Is exterior lighting provided in accordance with FAA? Yes

AD-A031 888 ARMY AVIATION TEST BOARD FORT RUCKER ALA F/G 1/3
MILITARY POTENTIAL TEST OF COMMERCIAL OFF-THE-SHELF HELICOPTERS--ETC(U)
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Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama 36362

USAARU-FO

29 July 1963

REPORT ON IH-2

1. Method of Testing.

a. The heating and ventilation evaluation of the IH-2 consisted of comparisons of outside air temperature and cockpit air temperature with the aircraft under all operating conditions. In conjunction with these checks, a carbon monoxide test was also made.

b. Equipment consisted of:

(1) Weston Aneroid Thermometer, Model 2291.

(2) Mine Safety Appliance Company Carbon Monoxide Tester, Category No. DS-47133.

2. Results. (See Annex A)

3. Discussion:

a. The recommended maximum temperatures for clothed men not especially acclimatized are as follows:

(1) Resting in still air - 88°F.

(2) Resting, with some air movement (170 FPM air velocity) - 93°F.

(3) Moderate work, still air - 78°F.

Reference: Patty, Frank A., Industrial Hygiene & Toxicology (2d ed., Vol. 1; New York: Interscience Publishers Inc., 1958).

b. The IH-2 while operating with existing outside air temperatures in the 90°F range meets the above listed requirements.

c. The largest percentage of carbon monoxide, 0.02%, was found with this aircraft at a hover with the doors on, windows closed, vents open. Maximum allowable concentration in a cockpit is 0.005% (50 ppm).

Reference: Air Force Manual No. 161-1, Flight Surgeon's Manual, Department of the Air Force.

d. Although this is considerably higher than the maximum allowable CO concentration, it would take approximately 80 minutes to develop a blood concentration of 10% CO, which is considered to be the upper limits. (These factors would not be constant --different weather conditions, i.e., wind, etc, would prevent maximum concentrations for extended periods of time). Approaching 25-30%, definite changes can occur which impair function.

Reference: Forbes, W. H., Sargent, F., and Roughton, F. J., "The Rate of Carbon Monoxide Uptake by Normal Man," American Journal of Physiology 143: 594, 1945.

e. A heater was not installed on this aircraft.

/s/ J. C. Rothwell
/t/ J. C. ROTHWELL
Captain, MSC
Ass't Chief, Avn Fld Opns Div

1 Incl
as

HEATING AND VENTILATION EVALUATION OF OFF-THE-SHELF HELICOPTER TRAINERS

REPORT ON IH-2

Analyzed by: S/Sgt. L. P. Parsons Date: 16 July 1963

	% CO		TEMP	
	A/C	Out	A/C	Out
VENTILATION				
On Ground				
Doors Off (P)	.01	-	90	90
Doors On - Window Open	.01	-	90	90
Doors On - Window Closed, Vent Open	-	-	100	90
Doors On - Window Closed, Vent Closed	-	-	98	90
Hover				
Doors Off (P)	.01	-	90	90
Doors On - Window Open	.0025	-	98	90
Doors On - Window Closed, Vent Open	.02	-	98	90
Doors On - Window Closed, Vent Closed	.0025	-	100	90
In-Flight				
Doors Off (P)	.005	-	88	84
Doors On - Window Open	.005	-	92	86
Doors On - Window Closed, Vent Open	.005	-	94	86
Doors On - Window Closed, Vent Closed	.005	-	102	86

HEATING*

*No heater installed

Annex A

Paragraph B

HEADQUARTERS
UNITED STATES ARMY AVIATION SCHOOL
FORT RUCKER, ALABAMA

AASDI 12 November 1963

SUBJECT: Off-the-Shelf Helicopter Mission Suitability Tests

TO: President
United States Army Aviation Test Board
Fort Rucker, Alabama

1. Inclosed corrected evaluation reports forwarded per your request.

2. This correspondence is marked "For Official Use Only" solely because of the addition of the inclosures. When the inclosures are removed, protective markings will be canceled.

FOR THE COMMANDANT:

/s/ M. J. Fayard
/t/ M. J. FAYARD
2d Lt. AGC
Asst Adjutant General

4 Incls
1. IH-1 Helicopter
2. IH-2 Helicopter
3. IH-3 Helicopter
4. IH-4 Helicopter

EVALUATION OF MISSION SUITABILITY OF THE IH-2 HELICOPTER AS CONDUCTED BY THE UNITED STATES ARMY AVIATION SCHOOL

1. Scope.

a. The IH-2 Helicopter was flown by Rotary Wing Instrument instructors from Department of Rotary Wing Training, US Army Aviation School (USAAVNS), for the purpose of evaluating its potential as a basic instrument trainer. This evaluation was conducted on the basis that the trainer is for use as a simulated instrument flight trainer only. Actual instrument flight capability was not considered. Tests were conducted in the vicinity of Fort Rucker, Alabama, performing basic maneuvers taught in the Army Helicopter Instrument Course.

b. The test aircraft and instruments furnished for evaluation were not of the configuration proposed as the final product by the manufacturer. The comments contained in this report pertain to the configuration of the test aircraft when modified by the manufacturer's technical proposal.

2. Findings.

a. Cockpit configuration.

(1) Instrument location. Unsatisfactory. The location of the student's stand-by compass on the right door frame is unsatisfactory. This location does not facilitate a rapid cross check, and causes the student to be distracted by outside reference.

(2) Instrument suitability. Unsatisfactory. The AR-1C attitude indicator proposed incorporates an integrated attitude indicator, and turn slip indicator. The turn indicator needle does not have the capability to indicate a steep turn because of limited needle travel.

(3) Radio Control Location. Satisfactory.

(4) Switch and Auxiliary Control Location. Unsatisfactory. The mixture control and carburetor heat controls were located in a position on the console that made them inaccessible to the student pilot when the instrument training hood was installed.

(5) Night Lighting. Undetermined. Suitability of instrument lighting could not be determined because the proposed configuration was not furnished for evaluation.

(6) Seating. Satisfactory.

(7) Storage space. Satisfactory. Detailed location of available storage space was not included in the manufacturer's technical proposal; however, the cabin size seems large enough to accommodate satisfactory storage provisions.

(8) Instrument Training Hood. Undetermined. A mockup of the proposed instrument panel, and instrument training hood was provided. This mockup could not be placed exactly in the position of a production panel because of the instrument panel in the test aircraft. The hood appears to be satisfactory but, a final determination of suitability could not be made.

b. Flight Characteristics. The IH-2 Helicopter was flown at weights varying from normal operating weight to maximum certificated gross weight. Maneuvers normally required for basic rotary wing instrument training were performed with particular attention toward controllability and in-flight stability. Attitude flight instruments were not furnished in the evaluation aircraft. Therefore, all maneuvers were performed with outside reference only.

(1) Controllability. Undetermined. Controllability is good in all maneuvers, but its suitability for instrument training could not be determined due to the lack of attitude flight instruments.

(2) In-flight Stability. Undetermined. Air stability during flight test varied from smooth to light turbulence. This aircraft exhibited satisfactorily pitch, roll, and yaw stability. Performance of the aircraft indicated reasonable stability could be anticipated in moderate turbulence. Determination of stability of the IH-2 for instrument training could not be determined because of the lack of flight attitude instruments.

(3) Basic Maneuver Performance. The following discrepancies were noted in addition to those listed above:

(a) Large attitude changes were required for transition from a hover to cruise speed.

(b) To perform left turns, a nose low attitude indication was required to maintain level flight.

(c) To perform right turns, a nose high attitude indication was required to maintain level flight.

(4) Proposed Radio Electronic Configuration. Satisfactory. Radio equipment, and antennae proposed in the IH-2 was found to be satisfactory; however, care should be taken to assure optimum location, and/or shielding of the DMN 4-4 VOR antenna to avoid problems of rotor modulation.

3. Conclusions.

a. The IH-2 Helicopter as proposed was found to be unsuitable in the area of mission suitability.

b. It is estimated that no major design changes in the IH-2 or associated proposal would be required to correct the deficiencies and shortcomings noted.

PARAGRAPH C

HEADQUARTERS
DEPARTMENT OF THE ARMY

Office of the Assistant Chief of Staff for Force Development
Board for Aviation Accident Research

Fort Rucker, Alabama

BAAR-OT 29 July 1963

SUBJECT: Summary of USABAAR's Evaluation of IH-2 Off-The-Shelf Basic Instrument Helicopter Trainer

TO: President
U. S. A. Aviation Test Board
ATTN: Off-the-Shelf Project Officer
Fort Rucker, Alabama

1. The following is USABAAR's evaluation of the IH-2 entry for the off-the-shelf instrument helicopter trainer competition. The evaluation considered the categories of aviation safety and accident prevention in three primary categories. In each of these categories, USABAAR found the aircraft to be acceptable for its intended mission. However, there are certain deficiencies which will detract from its mission capability and should be considered by those responsible for selecting the winner of the competition. Categories considered are:

a. Operational Safety: This category considers those features of the aircraft and its operating characteristics that are considered to be conducive to accident causation and which may detract from the operator's ability to maintain safe flight at all times.

b. Maintenance Safety. This category considers maintenance design features of the aircraft contributing to accident causation. It includes those features of "Murphy's Law", ease of inspection, accessibility for component replacement, the preflight inspections imposed on the operator, etc.

BAAR-OT 29 July 1963
SUBJECT: Summary of USABAAR's Evaluation of IH-2 Off-the-Shelf Basic Instrument Helicopter Trainer

c. Crashworthiness: This category considers design features of the aircraft that, in the event of a crash, provide protection to the occupants from injury. It also includes features of crash-fire worthiness.

2. Evaluation comments are as follows:

a. Operational Safety:

(1) The location of the engine supercharger housing and exhaust gases outlets are such that grass fires are a danger when operating in such areas.

(2) Vibrations at 70 MPH indicated airspeed and at or near gross loads, causes some difficulty in reading the instruments. When the airspeed is reduced to 60 MPH, read-out of the instruments improves.

(3) Rate of climb is very slow at maximum manifold pressure and RPM.

(4) The hydraulic boost control switch is located in the lower portion of the pedestal which makes it difficult to reach in the event of a failure in this system. A failure during nap-of-the-earth flying or at a hover requires the pilot to release the collective pitch control to activate this switch. USABAAR has on record two accidents in which the hydraulic boost control failed during hovering and the pilot was unable or did not desire to release his control to shut the system off.

b. Maintenance Safety:

The fuel selector valve control connection located in the tail boom area, aft of the engine, can be damaged or malaligned quite easily when climbing the boom for rotor mast inspection.

BAAR-OT 29 July 1963
SUBJECT: Summary of USABAAR's Evaluation of IH-2 Off-the-Shelf Basic Instrument Helicopter Trainer

c. Crash Worthiness:

(1) The post-crash fire potential of this aircraft appears to be even greater than that of other twin tank models. Increased fuel capacity, outboard location of the fuel tanks and extra ignition surface provided by the supercharger add to the potential. USABAAR considers this aircraft unacceptable in the crashworthiness category because of this.

(2) The energy absorption qualities of the seat cushions in this aircraft are inferior to those used in other Army aircraft.

3. The following features are recognized as desirable and considered worthy of mention.

a. Night lighting was found to be very good. No reflections were caused in the bubble from either the anti-collision lights, navigation lights, or instrument panel lights. The tinted bubble affords ease of eye strain during day and night operation.

b. Due to the high inertia main rotor blades, the aircraft is extremely easy to autorotate.

c. The stability of this aircraft is such that the aircraft can be flown hands-off for periods of 15 - 30 seconds.

/s/ Robert M. Hamilton
/t/ ROBERT M. HAMILTON
Colonel, Infantry
Director, USABAAR

PARAGRAPH D

Human Factors Evaluation of the IH-2 (Inst.) Aircraft

1. Summary

1.1 With regard to human factors considerations of the crew area, the IH-2 is acceptable for use as a two-place basic instrument trainer, with the following exceptions: The ignition switch is located so that it is susceptible to inadvertent activation, visibility on the right side is restricted, warning lights are not utilized on the instrument panel, the seats are not adjustable, and the student cannot reach the carburetor air and mixture controls.

2. Detailed Considerations

2.1 The proximity of the ignition switch to the radio tuning controls, and in a position between the student and the radio controls vitiates trouble-free training. The switch should be surrounded by a raised guard as high as the switch itself, or moved to the upper panel or to the left of the radios.

2.2 Sufficient information has not been submitted to allow a thorough evaluation of the "blind flying hood."

2.2.1 On the basis of the photograph of the proposed instrument panel configuration, and "blind flying hood" surrounding it, the student's vision will be limited to the instrument panel area.

2.2.2 The hood surrounding the instrument panel acutely restricts the vision of both pilots so that clearing for maneuvers to the right will be difficult. A convex mirror above the student's head may assist the instructor in clearing to the right.

2.3 Consistent with the effort to increase safety through communication of status information, consideration should be given to the addition of a warning light panel on the lower left corner of the upper instrument panel, or the lower right portion of the lower instrument panel.

2.3.1 Warning lights should include hydraulic pressure, engine oil pressure, 20 minute fuel, and generator.

2.4 The adjustability of the pedals does not fully compensate for the non-adjustability of the seats. Fore and aft seat adjustment for confortable positioning for cyclic manipulation would contribute to the suitability of the cockpit configuration for training purposes.

2.5 The carburetor air and mixture controls are located to the left (instructor's side) of the "blind flying hood" in the proposed configuration. It is considered desirable that the student be able to manipulate these controls rather than tell the instructor when to do so. With the controls inside the "blind flying hood" the student could practice the procedural skills realistically and greater positive transfer of training may be expected than with the proposed configuration.

/s/ H. Alton Boyd, Jr.
/t/ H. ALTON BOYD, JR.
Research Associate

UNIT C - COMPANY A MODEL IH-3

SECTION ONE

USAAVNTBD REPORT

A. Description of Materiel.

1. The IH-3 is a single-engine, three-place, side-by-side, two-bladed single main-rotor- and tail-rotor-type helicopter. Power is supplied by a VO 540-B1D six-cylinder, opposed type air-cooled engine which has a maximum continuous power rating of 305 b.hp. at 3200 r.p.m. Engine power is transmitted to the rotors through a double planetary reduction transmission. The main-rotor mast assembly is set into the transmission, which is bolted to the engine, making the complete assembly one rigid unit. Takeoff shaft connections extend from the transmission to drive the tail (antitorque) rotor.

2. Flight controls consist of a cyclic stick, collective pitch stick, and antitorque pedals. A motor-driven-type cyclic trim system is provided. An adjustable friction device is provided for the collective pitch.

3. The main rotor system is a two-bladed, teetering, underslung rotor. Aerodynamic "paddles" are mounted at 90 degrees to each main-rotor blade and are linked through the fixed and rotating swash plates and push-pull tubes to the cyclic controls to provide pitch and roll control of the helicopter. A two-bladed, all-metal, antitorque tail rotor mounted on flapping hinges provides a means for directional control.

4. The helicopter basic body section and tail boom are of all-metal stressed-skin construction with a tinted plexiglass bubble. A baggage compartment with 125-pound capacity is located aft of the tail-cone attaching point. A 1000-pound-capacity cargo hook with manual and electrical releases is provided. The helicopter has a skid-type landing gear with removable ground-handling wheels.

5. General dimensions of the helicopter submitted for test are listed below:

a. Overall height	10 feet 2 inches

b.	Overall length(main rotor tip to tail rotor tip)	40 feet 6 inches
c.	Rotor diameter	35 feet
d.	Fuselage width	4 feet 1. inches
e.	Skidgear tread	7 feet 6 inches

B. Scope of Tests. The test was conducted in the vicinity of Fort Rucker, Alabama, by USAAVNTBD project officers and USAAVNS rotary-wing instrument instructors. The test consisted of three phases: a 25-flying-hour evaluation; a thorough study of the manufacturer's technical proposal which described changes to be made to configure the test helicopter to meet the stated requirements; and a comparison of the helicopter with the Model Specification and the Statement of Requirement. In addition, the US Army Board for Aviation Accident Research (USABAAR) evaluated the aviation safety aspect; the US Army Aviation Human Research Unit (USAAHUMRU) evaluated the human factor aspects; and the US Army Aeromedical Research Unit (USAARU) evaluated noise level, internal lighting, and heating and ventilation. Complete reports as received from each of these units are contained in Section Two.

C. Tests.

1. Evaluation of Physical and Flight Characteristics, Performance, and Maintenance.

a. Physical Characteristics.

(1) Basic Weight. The basic weight was determined by weighing the helicopter as delivered with oil and trapped fuel. To this weight (1844 pounds), the weight of electronic and auxiliary equipment required for Army use (212 pounds) was added, and the weight of currently-installed equipment not required for Army use (82 pounds) was subtracted, resulting in a total estimated basic weight of 1974 pounds. The estimated mission operating weight was then computed by adding to the estimated basic weight the weight of fuel (276 pounds) and 450 pounds (instructor, student, and instructional equipment). Details follow:

EMPTY WEIGHT as weighed (less ground-handling wheels)		1844 lb.
Weight of required equipment to be added:		
Shoulder harness and inertia reel (2 ea.)	6	
First aid kit and fire extinguisher	10	
AN/ARC-45 UHF	27	
C-1611 interphone (2 ea.)	4	
VOR, Type 15F	27	
ADF, Type 21A	23	
MB/GS	9	
Heading Reference, SPC-1	5	
RMI, C-6-H	5	
Generator, 125-amp.	38	
RMI Converter, B-18A	4	
Instrument training hood	5	
Antenna, AT-450/ARC	1	
Battery, MA-7	34	
Inverters (2 ea.)	14	
TOTAL ADDED	212 lb.	212 lb.
		2056 lb.

Weight (brought forward)		2056 lb.
Weight of installed equipment to be removed:		
Commercial radio	8	
Rate gyro	1	
Transformer	2	
Directional gyro	3	
Inverter	7	
Miscellaneous plumbing	4	
Generator, 50-amp.	20	
Battery	28	
External cargo hook	9	
TOTAL SUBTRACTED	82 lb.	-82 lb.
BASIC WEIGHT (ESTIMATED)		1974 lb.
Fuel, main tank (46 gal.)	276 lb.	
Instructor pilot, student, instructional equipment	450 lb.	
	726 lb.	726 lb.
Mission Operating Weight (Estimated)		2700 lb.
Remaining Available Payload		100 lb.
Maximum Certificated Gross Weight		2800 lb.

(2) Ground-Handling Characteristics. Ground-handling characteristics were satisfactory, utilizing the removable ground-handling wheels provided with the helicopter.

(3) Adequacy of the Cockpit Configuration and Arrangement. The cockpit configuration and arrangement of the test helicopter were evaluated except for those items changed in the manufacturer's technical proposal. The cockpit configuration and arrangement were satisfactory except for the following:

(a) Collective throttle friction required rotation in a clockwise direction to tighten. Engine power can inadvertently be decreased when increasing throttle friction.

(b) Installed seat belts did not meet military specifications.

(4) Noise Level. Overall internal and external sound pressure levels were acceptable. However, numerous internal measurements exceed the military specifications for acoustical noise levels in Army aircraft (MIL-A-8806) (paragraph A, section two).

(5) Suitability of External Lighting. External lighting was satisfactory and met the Model Specification requirements.

(6) In-Flight Visibility. Visibility from the instructor-pilot seat was satisfactory except for the pilot and copilot door frames.

(7) Heating and Ventilation. An accurate evaluation of the heating system could not be accomplished because facilities were not available at Fort Rucker to control outside air temperatures. Ventilation was adequate (paragraph A, section two).

(8) Suitability for Hoisting, Jacking, and Mooring. The helicopter was equipped with suitable jacking points and had suitable locations on the structure for attachment of mooring lines. Special hoisting straps, presently in the Army system, are required for hoisting the helicopter.

(9) Suitability of External Power Receptacle. The helicopter was equipped with an external power receptacle that was compatible with the Army's APU's.

(10) Center-of-Gravity Travel. The CG of the helicopter remained within limits without addition of ballast or relocation of components regardless of changes in loading of the helicopter with respect to fuel, instructor pilot, and student.

b. Flight Characteristics. The helicopter was flown at weights varying from mission operating weight (2700 pounds) to maximum certificated gross weight (2800 pounds). Maneuvers normally required of a rotary-wing basic instrument trainer were performed with particular attention toward controllability and in-flight stability. The flight characteristics of the IH-3 as a basic instrument trainer were unsatisfactory because of the following:

(1) Controllability.

(a) Cyclic and collective pitch control forces were excessive.

(b) Precise trim adjustments required for attitude instrument flying were very difficult due to the nature of the motoring trim device. Heavy control forces on the cyclic stick precluded instrument operation without the use of the cyclic stick trim device.

(c) Large changes in pitch attitude were required for transition from a hover to a cruise of 70 knots. These attitude changes are undesirable for student instrument training, but are inherent in a helicopter of this size.

(2) In-flight Stability. Stability of the IH-3 was evaluated in pitch, roll, and yaw. Smooth-to-moderately turbulent air was encountered during the flight test period. Definite yaw instability existed in light turbulence and was most prevalent at low speeds, and/or low power settings. This resulted in rapid oscillation of the turn indicator. Stability around all axes was unsatisfactory in moderate turbulence.

(3) Autorotational Characteristics. The autorotational characteristics of the test aircraft were satisfactory.

c. Performance. The helicopter was flown at both mission operating weight (2700 pounds) and maximum certificated gross weight (2800 pounds) to determine whether it met the performance criteria of Model Specification. The following were determined:

(1) Maximum cruise airspeed (true) at 5000 feet m. s. l. (standard conditions) was limited to Vne of 83 knots.

(2) Endurance at 5000 feet m.s.l. (standard conditions) at 70 knots (true airspeed) was 2.6 hours.

d. Maintenance.

(1) During the evaluation, the helicopter was maintained by the manufacturer's representative with military personnel provided for servicing, general assistance, and maintenance of records.

(2) Throughout the evaluation, 80/87 octane fuel was used because of the particular engine installed. However, the VO 540-9 engine included in the manufacturer's technical proposal will operate satisfactorily on standard Army aviation fuel (115/145) and lubricants.

(3) The helicopter was easy to service and maintain. All major components were readily accessible; however, no replacements were required during the evaluation.

(4) Tools and ground support equipment normally found at the organizational level were adequate for organizational maintenance. Special tools are required for higher echelons of maintenance.

2. Evaluation of Manufacturer's Technical Proposal. A thorough study was made of the manufacturer's technical proposal which described changes to reconfigure the test helicopter to meet the stated requirements. The following were determined:

a. Adequacy of Cockpit Configuration and Arrangement.

(1) Location of collective stick friction was not satisfactory with left-right seating proposed.

(2) Adjustable control pedals were satisfactory.

(3) Seat belts and shoulder harnesses with inertia reels for all occupants were included in the technical proposal; however, suitability could not be determined.

(4) Floor-mounted and cyclic-control-mounted radio-interphone switches were provided for both student pilot and instructor.

(5) Drawings of the instrument training hood in the manufacturer's technical proposal appeared to provide a satisfactory approach to the problem of providing an instrument training hood. A mockup of the hood was not provided; therefore, a determination of its suitability could not be made. The instrument training hood appeared to provide a minimum of obstruction to the instructor pilot's outside vision. Additional consideration should be given to providing a shield for the lower part of the student pilot's door to prevent possible visual distraction. Material proposed and method of installation of the instrument training hood appeared to be satisfactory; however, it would be more desirable if the panels installed on top of the instrument console could be collapsed for increased student visibility in the event of an emergency.

(6) The position of the manifold pressure bleed-air control was undetermined in the technical proposal. The location in the test helicopter on the left side of the instrument console was undesirable.

(7) Detailed location of available storage space was not included in the manufacturer's technical proposal; however, the cockpit appeared large enough for adequate storage of instructional material.

b. Suitability of Internal Lighting. The cockpit instrument panel illumination met Model Specification requirements although numerous unsatisfactory conditions were noted (reference paragraph A, section two).

c. Instrumentation and Panel Arrangement Proposal.

(1) The instrument panel was configured in a front-mounted panel, standard "T" arrangement.

(2) All flight and navigational instruments required by the Model Specification were provided.

(3) The manufacturer's proposal for a production panel configuration and instrument arrangement was satisfactory except for the turn-and-slip indicator. The use of the proposed attitude indicator (AR-1C) with an integral horizontal bar turn-and-slip indicator was considered unsuitable. If operating on partial panel no reference

would be available to determine the rate of turn when greater than standard rate, because the maximum travel of the turn indicator is limited to turns slightly greater than standard rate.*

(4) A manifold pressure indicator and engine tachometer were provided.

(5) Switches and auxiliary controls necessary for flight and navigation as shown in the technical proposal were accessible and were within reach of the student pilot and instructor.

(6) The radio control panel as shown in the technical proposal was accessible, both visually and physically, to the student and instructor pilot.

(7) No information was available to determine suitability of the proposed SPC-1 heading reference.

d. Mission Suitability. The IH-3 Helicopter as proposed was unsuitable in the area of mission suitability. (See paragraph B, section two, for the complete report from the USAAVNS.)

e. Electronic Configuration. The helicopter provided for evaluation was not equipped with the electronic equipment specified in appendix I of the Model Specification. The manufacturer's proposal submitted with the helicopter specified the location and installation of all electronic components. The proposed electronic configuration was unsatisfactory because of the following:

(1) The ram's horn VOR antenna with the combined ILS glide slope antenna (AS-580-A) is located on the top of the bubble. This antenna and location indicate that an unsatisfactory performance would occur due to rotor modulation. (See USAAVNS report, paragraph B, section two, for additional information.)

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*The manufacturer provided a bread-board installation of the proposed five-inch attitude indicator which included a four-minute turn-and-slip indicator. Considerable difficulty was experienced interpreting rate of turn because of the helicopter yaw instability which resulted in a rapid oscillation of the turn indicator. This problem was partially alleviated by the installation of an oscillation damper that slowed the needle rate on the turn indicator. The proposal has been revised to include a rate damper in production aircraft.

(2) No provisions were indicated for ventilation of the after electronic compartment.

f. Aviation Safety. The evaluation considered the categories of operational safety, maintenance safety, and crashworthiness. In each of these categories, USABAAR found the aircraft to be acceptable for its intended mission. Certain discrepancies which would detract from its mission capability were noted (see paragraph C, section two, for complete report).

g. Human Factors. The human factors design of the IH-3 was found to be adequate for mission accomplishment with the exception of the method for trimming out cyclic stick forces (paragraph D, section two).

3. Comparison with Model Specification and Statement of Requirement. The extent to which the IH-3 met the requirements of the Model Specification and Statement of Requirement was determined by consideration of the characteristics of the helicopter as tested and an evaluation of the manufacturer's technical proposal.

a. Comparison with Model Specification.

Mod. Spec. Para.No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
1.	SCOPE.		
1.1	Scope. This detailed specification covers the essential requirements for the design of a single-engine helicopter basic instrument trainer capable of performing the mission specified in 1.2.		
1.1.1	Designation and General Description. Army Model Designation - Helicopter Basic Instrument Trainer (model number not yet assigned).		

Mod. Spec. Para. No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
	Number of crew - 1 pilot	Yes	
	Number of passengers - 1 student	Yes	
	Crew and passenger seating arrangement - side by side (instructor pilot on the left).	Yes	
	Flight controls - dual	Yes	
	Main-rotor system - single	Yes	
1.2	Mission. The primary Army mission for which this helicopter will be employed is training of military pilots in helicopter instrument flying. Training will be accomplished under simulated instrument flight conditions.	No	See USAAVNS report for complete details (paragraph B, section two).
1.3	Federal Aviation Agency Certification. The helicopter will have a part 6 standard airworthiness certificate issued by the Federal Aviation Agency.	Yes	
1.4	Performance Information. Those items of performance stated as requirements herein which are not included in the FAA-approved flight manual are subject to verification by the US Army.	Not required.	

Mod. Spec. Para. No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
2.	APPLICABLE DOCUMENTS.		
2.1	The documents applicable to this specification are those necessary to fulfill the requirements of paragraph 1.3, Federal Aviation Agency Certification.	Yes	
3.	REQUIREMENTS.		
3.1	Basic Weight. The basic weight of the helicopter will include all required installed equipment including the avionics as stated in paragraph 3.7.1, 3.8.1.1, 3.8.1.2, and 3.10.1.	Yes	
3.2	Center-of-Gravity Travel. Addition, removal, or relocation of ballast or aircraft components will not be necessary in order to maintain the CG within CG limits due to changes in loading of the helicopter with respect to fuel, pilot, and student.	Yes	
3.3	Required Performance.		
3.3.1	NASA Standard Day Conditions (at certificated gross weight).		
	Cruise speed (minimum) - 70 knots at 5000 feet m.s.l.	Yes	Maximum cruise speed obtained

Mod. Spec. Para. No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
			was limited to 83 knots (Vne).
	Endurance (minimum) 2 1/2 hours at 70 knots cruise speed at 5000 feet m.s.l.	Yes	Maximum endurance was 2.6 hours.
3.3.2	Useful Load. The useful load of the helicopter will be sufficient for 450 pounds in addition to fuel and oil necessary to accomplish the 2 1/2 hours endurance performance mission specified in paragraph 3.3.1	Yes	Remaining available payload was 100 pounds with full fuel.
3.4	Aircraft Structure.		
3.4.1	Landing Gear.		
3.4.1.1	Type Landing Gear. Type of landing gear is optional.	Yes	Skid-type gear was utilized.
3.4.1.2	Ground Handling. Ground-handling wheels are required. Weight of the ground-handling wheels will not be included in the weight empty if they are detachable.	Yes	
3.4.1.3	Hoisting, Jacking, and Mooring. Provisions will be made for hoisting, jacking, and mooring.	Yes*	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
3.5	Operating Environment.		
3.5.1	Aircraft Operation. The aircraft will be capable of operating in temperatures from 0°F. to +100°F.	Undetermined	Manufacturer's proposal indicates helicopter is capable of operation in temperatures from 0°F. to +100°F. Temperatures during test period varied from +75°F. to +95°F. No difficulties were noted.
3.5.2	Cabin Heating. The aircraft will have a heating system which provides a minimum of 50°F. cabin temperature, with 0°F. outside air temperature. This condition need only be satisfied with the engine operating.	Undetermined	A cabin heating system was provided. See US Army Aeromedical Research Unit Report, paragraph A, section two.
3.5.3	Defrosters. This aircraft will include defrosters on both sides of the windshield.	Yes*	Defrosters were incorporated with the cabin heater.
3.6	Fuel and Lubricants. The engine will operate on such fuel and lubricants which are now established as standard by the US Army. (Reference MIL-G-5572C dated 12 July	Yes*	The IH-3 was operated on 80/87 octane gasoline and Army non-detergent oil during conduct of the

*Not tested; included in the technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
	1960, MIL-L-22851 dated 30 July 1961, MIL-L-6082C dated 18 May 1961.)		test. Manufacturer's technical proposal indicated engine proposed would operate on 115/145 octane fuel.
3.7	Instruments and Navigation Equipment. Flight instruments and lights for day and night VFR flight conditions will be furnished and installed by the contractor. Standard "T" arrangement, front mounted panel, is required. Instrument panel will be arranged to permit unobstructed vision of instruments by the instructor pilot and student pilot.	Yes*	
3.7.1	Navigational Group. The following instruments are required:		
	Attitude indicator - five-inch, non-precessing, non-tumbling type.	Yes*	The indicator must provide adequate pitch and roll adjustment.
	Heading indicator - three-inch, radio magnetic indicator (RMI) type.	Yes*	

*Not tested; included in the technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
	Vertical-speed indicator - instantaneous type.	Yes*	
	Altimeter - sensitive, barometric.	Yes	
	Airspeed indicator - (indicated in knots).	Yes*	
	Turn-and-slip indicator - four-minute turn needle.	Yes*	Incorporated in AR-1C attitude indicator but considered unsuitable.
	Magnetic compass - located for easy reference by student pilot and instructor pilot.	Yes*	
	Clock - elapsed time.	Yes*	
3.7.2	Power Group.		
	a. For reciprocating engine: a manifold pressure indicator and engine/main rotor tachometer are required.		
	b. For turbine engine: a gas producer indicator, torquemeter, and engine/main rotor tachometer are required.	N/A	

*Not tested; included in the technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
3.8	Electrical.		
3.8.1	Lighting.		
3.8.1.1	Anti-Collision Light. The aircraft will have an anti-collision light. The light will be located to prevent reflection into the cockpit.	Yes	
3.8.1.2	Landing Light(s). The aircraft will be equipped with landing lights which will be adjustable. The landing light switch will be located on the pilot's cyclic or collective controls.	Yes	Landing light was manually adjustable on the ground.
3.8.2	Power Receptacle. The aircraft will be equipped with an external power receptacle of an AN or AMS standard design.	Yes	
3.8.3	Switches and Auxiliary Controls. All switches and auxiliary controls necessary for flight and navigation will be accessible and within reach of the student pilot and the instructor pilot. Switches and controls shall be operable in flight by personnel wearing winter flight clothing. Accessible	Yes*	

*Not tested; included in the technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
	floor mounted and cyclic control mounted radio-interphone switches will be provided for both student pilot and instructor.		
3.9	Other Equipment and Requirements.		
3.9.1	Instrument Training Hood. A permanent type hooded device which will allow the student to observe the instruments and not allow observance outside the aircraft will be provided. This device will not obstruct the vision of the instructor pilot.	Undetermined*	It would be more desirable if the panels installed on top of the instrument console could be collapsed for increased student visibility in the event of an emergency. See paragraph B, section two, for complete details.
3.9.2	Safety Equipment. Seat belt and shoulder harness for all occupants will be provided.	Yes*	Shoulder harness with inertial reels were provided in the technical proposal.
3.9.3	Control Pedals. Adjustable control pedals will be provided.	Yes*	
3.9.4	Storage Space. Storage space for navigational equipment such as maps, charts,	Yes	

*Not tested; included in the technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
	computers, and navigational kit (TM 11-2557) will be provided.		
3.10	Avionics.		
3.10.1	Electronic Equipment. The aircraft will be equipped with electronic equipment as indicated in appendix I.	Yes*	
3.10.2	Radio Control Panel. Must be accessible, both visually and physically, to the student pilot and the instructor pilot. Overhead location is not acceptable.	Yes*	
	APPENDIX I		
	Communications.		
	UHF - AN/ARC-45, 1 ea.	Yes*	
	ICS - C-1611, 2 ea.	Yes*	
	Navigation.		
	VOR - Aircraft Radio Corp. Type 15F, 1 ea.	Yes*	
	RMI Converter - ARC Type B18A	Yes*	
	ADF - Aircraft Radio Corp. Type 21A, 1 ea.	Yes*	

*Not tested; included in the technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-3 Meets Spec.	Remarks
	MB/GS - Collins/Babcock, 1 ea. (Marker Beacon Glide Slope Receiver to be commercial counter-part of R-844, if available.)	Yes*	
	Heading reference, 1 ea. (Contractor selected and furnished systems having capabilities equal to or superior to Army standard J-2 compass (commercial C-4). Equipment will be furnished with C-6H indicator. The selected system shall be qualified to FAA Technical Standard Order C6C and shall bear TSO Type A certification decals.)	Undetermined*	No information was available to determine suitability of the proposed SPC-1 heading reference.
	Instrumentation.		
	RMI - Sperry C-6H, 1 ea.	Yes*	
	Miscellaneous.		
	Antenna - AT-450/ARC, 1 ea.	Yes*	
	Battery, Sonotone, MA-7, 1 ea.	Yes*	
	Inverter - Leland MG-E-93-200 or Bendix 328-172-1, 2 each.	Yes*	Leland MG-E-93-200 is proposed.

*Not tested; included in technical proposal.

(b) Comparison with Statement of Requirement.

A comparison with the Statement of Requirement (reference 3), excluding those requirements covered by the Model Specification, is as follows:

Performance. Unless otherwise specified, the following should be attained at NASA standard conditions with an instructor pilot, one student pilot, and fuel for 2.5 hours endurance at normal cruise.

Requirement	IH-3 Meets Requirement	Remarks
Cruise airspeed (standard day) 5000' m.s.l. (knots):		
Essential - 70	Yes	Maximum cruise speed was limited to 83 knots Vne.
Desired - 90	No	
Endurance (at cruise airspeed) 5000' m.s.l., no reserve (hours):		
Essential - 2.5	Yes	Maximum endurance obtained was 2.6 hours.
Desired - 3.5	No	
Stability - adequate yaw, roll, and pitch stability in light to moderate turbulence.	No	See USAAVNS report for details (paragraph B, section two).
Cabin Arrangement.		
Windshields constructed of material highly resistant to scratching.	Yes	Latest state-of-the-art material is used for bubble. No scratches were acquired during conduct of evaluation.

Requirement	IH-3 Meets Requirement	Remarks
Warning lights on panel to include fuel, oil, hydraulic and electrical systems. (Desired)	Yes*	
Earphone and microphone jacks and cords compatible with APH-5 helmet for all occupants.	Yes*	
Personnel Considerations.		
No new personnel skills will be required.	Yes	Due to the similarity to other helicopters in the Army, no new personnel skills will be required.
Training Considerations.		
No new training requirements will be generated.	Yes	No additional service schools will be required.
No supporting training devices other than those on hand at the US Army Training Base are required.	Yes	

D. Deficiencies and Shortcomings.

1. The following deficiencies were noted:

a. Adequate stability was not provided in light-to-moderate turbulence.

b. Use of a ram's horn antenna in helicopters has proved unsatisfactory in the past.

c. No provisions were indicated for ventilation of after electronic compartment.

*Not tested; included in the technical proposal.

d. Aircraft cyclic and collective pitch control forces were excessive.

e. Motoring trim device was unsuitable.

f. Turn-and-slip indicator incorporated in AR-1C attitude indicator was unsuitable.

g. Location of collective pitch stick friction was not satisfactory with left-right seating proposed.

2. The following shortcomings were noted:

a. Instrument and radio control panel lighting could not be independently controlled.

b. The cockpit door frames restricted visibility.

c. Clockwise rotation of collective throttle friction was unconventional.

d. Location of manifold pressure bleed air control was undesirable.

e. Tail boom "Pogo" sticks are not substantial.

f. Short skid shoe installation exposed skid shoes to catch on ground objects.

g. Magnetic chip detectors were not installed in the engine and transmission oil sumps.

h. There were inadequate provisions for "step here" areas on which to stand while pre-flighting the rotor head.

i. There was no overhead protection for personnel in the event of a crash in which the helicopter turns over.

SECTION TWO

Reports From Other Agencies on the IH-3

Paragraph A

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama 36362

USAARU-FO 6 August 1963

LIGHT EVALUATION OF THE IH-3

1. Methods and Equipment.

a. The evaluation consisted of in-flight analysis of the aircraft's lighting system under night conditions. Criteria for this evaluation were derived from U. S. Navy Specifications governing cockpit and instrument panel illumination modified to meet Army requirements.

b. A standard Norwood photo-electric meter was used to measure overall cockpit illumination from the auxiliary hand light or map light.

2. Results. (See Annex A)

3. Discussion.

a. Reflections from the instrument panel lights were noted on the right and left sides of the bubble.

b. Reflections from the grey painted cockpit interior were noted on the bubble.

c. Warning and caution lights should be dimmed for night operations to safeguard the pilot's night vision (Transmission Oil Pressure, Transmission Oil Temperature).

d. The Grimes anticollision light mounted on the mast produced a stroboscopic reflection on the rotor blades. The reflection is reduced to a minimum due to the flat black paint on the rotor blades. However, as the blade surfaces wear and become shiny, or if other light colored blades are installed, the stroboscopic reflection could present a problem.

USAARU-FO 6 August 1963

4. Summary. If the deficiencies mentioned above are corrected, the aircraft will meet military illumination standards for an instrument trainer capable of performing night training missions.

1 Incl
as

/s/ William C. Thrasher
/t/ WILLIAM C. THRASHER
2/Lt., MSC
Ass't Chief, Avn Fld Opns Div

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama

COCKPIT LIGHT STUDY
IH-3

1. Are all instruments adequately illuminated? Yes.

2. Are they illuminated uniformly? Yes. Is there sufficient intensity? Yes.

3. Is illumination controllable to very low intensities? Yes (Rheostat)

4. Are markings of instruments readable? Yes.

5. Are all controls, instructions, and nameplates adequately illuminated? Yes.

6. Are they illuminated uniformly? Yes. Is there sufficient intensity? Yes.

7. Is illumination controllable to very low intensities? Yes.

8. Are markings on controls, instructions and nameplates readable? No.

9. Is the intensity of lighting for some instruments and controls controlled separately? Yes.

10. Is flood lighting provided? Yes. Is the light standard red? Yes (also white light).

11. Is the power source independent of normal lighting circuit? Yes.

12. Are there any sources of light which give other than standard red light? No.

13. Are there any reflections in the windshield, windows, canopy or other reflecting surfaces which interfere with visibility inside or outside the cockpit? Yes (note para. 3.a.b.).

14. Is there light leakage into the cockpit from other compartments? No.

15. Are all instruments, instructions, nameplates, and control markings readable in daylight? Yes.

16. Can warning and caution lights be dimmed sufficiently for night operations? No (note para 3.c.).

17. Are warning and caution lights of sufficient intensity for daylight use? Yes.

18. Are warning and caution lights on the main dimming circuit? No.

19. Is lighting provided in accordance with the aircraft detail specification? N/A.

20. Is the auxiliary light adequate for reading? Yes.

21. Does the light cause glare to cockpit? No.

22. Is there adequate general illumination for the compartment? Yes.

23. Do any of the exterior lights provide glare in the cockpit? No. (note para 3.d.).

24. Is exterior lighting provided in accordance with FAA? Yes.

Map light rated at 32 footcandles with the light 14 inches from the photometer.

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama 36362

USAARU-FO 6 August 1963

REPORT ON IH-3

1. Method of Testing.

a. The heating and ventilation evaluation of the IH-3 model consisted of comparisons of outside air temperature and cockpit air temperature with the aircraft under all operating conditions In conjunction with these checks, a carbon monoxide test was also made.

b. Equipment consisted of:

(1) Weston Aneroid Thermometer, Model 2291.

(2) Mine Safety Appliance Company Carbon Monoxide Tester, Category No. DS-47133.

2. Results. (See Annex A).

3. Discussion.

a. Although high temperatures were encountered on the aircraft with doors on, windows closed, and vents closed (see Annex A), this aircraft will rarely if ever, be operated under these conditions with existing outside temperature 86°F.

b. The recommended maximum temperatures for clothed men not especially acclimatized are as follows:

(1) Resting in still air - 88°F.

(2) Resting with some air movement (170 FPM air velocity) -93°F.

(3) Moderate work, still air -78°F.

Reference: Patty, Frank A., Industrial Hygiene & Toxicology (2d ed., Vol. 1; New York: Interscience Publishers Inc., 1958).

USAARU-FO
SUBJECT: Report on IH-3 6 August 1963

c. Comparing recommended working temperatures (see above) with temperatures found in aircraft (see Annex A), a mean working temperature of 95°F was derived.

d. Carbon monoxide was not found in this aircraft at any time.

e. Heater was not checked on this aircraft due to extreme outside temperatures.

1 Incl
as

/s/ J. C. Rothwell
/t/ J. C. ROTHWELL
Captain, MSC
Ass't Chief, Avn Fld Opns Div

IH-3

HEATING AND VENTILATION EVALUATION OF OFF-THE-SHELF HELICOPTER TRAINERS

Analyzed by: Captain Rothwell Date: 6 August 1963

	%CO		Temp	
	A/C	Out	A/C	Out
VENTILATION				
On Ground				
Doors Off (P)	0	0	92°F	86°F
Doors On - Window Open	0	0	----	----
Doors On - Window Closed, Vent Open	0	0	96°F	86°F
Doors On - Window Closed, Vent Closed	0	0	102°F	86°F
Hover				
Doors Off (P)	0	0	92°F	86°F
Doors On - Window Open	0	0	----	----
Doors On - Window Closed, Vent Open	0	0	102°F	86°F
Doors On - Window Closed, Vent Closed	0	0	104°F	86°F
In-Flight				
Doors Off (P)	0	0	84°F	83°F
Doors On - Window Open	0	0	----	----
Doors On - Window Closed, Vent Open	0	0	90°F	83°F
Doors On - Window Closed, Vent Closed	0	0	100°F	83°F

HEATING*

*Heat check not performed.

Annex A

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama 36362

USAARU-FO 6 August 1963

NOISE EVALUATION OF THE IH-3

1. Methods and Equipment.

a. Due to the number of aircraft to be tested and the short time available, the noise analysis was limited to the following:

(1) "A" - 24-55 db: sound level for speech interference.

(2) "B" - 55-85 db: sound level for noise survey.

(3) "C" - 85-140 db: sound pressure level--over-all frequency response.

b. A General Radio, Sound-Level-Meter, type 1551-C, was used for the noise measurements.

c. The test area, located at County Line Strip, is a pre-marked compass rose with a 50 foot radius.

2. Results. (See Annex A)

3. Discussion.

	Doors On	Doors Off	MIL-A-8806
Normal cruise	107	115	106
Maximum cruise	113	118	113

a. Operation of this helicopter at normal and maximum cruise with the doors on and off produced excessive sound pressure levels as shown above. These noise levels exceed Tables I and IV MIL-A-8806.

b. There are no military specifications for external noise. Raw data is included for purpose of comparison only.

USAARU-FO 6 August 1963
SUBJECT: Noise Evaluation of the IH-3

4. Summary. Improvements should be made to reduce noise levels to meet military specifications (MIL-A-8806).

/s/ William C. Thrasher
/t/ WILLIAM C. THRASHER
2/Lt., MSC
Ass't Chief, Avn Fld Opns Div

1 Incl
as

NOISE LEVEL MEASUREMENTS-OCTAVE BAND ANALYSIS

DATA COLLECTION SHEET

Analyzed by Sgt. Parsons Date 1 August 1963

IH-3

DOORS-ON	A	B	C	Center	Student	Air Speed	Manifold	RPM	Radius
Ground idle	98	105	108		x		10.5"	2200	
Ground high power	96	100	102		x		13.7"	3200	
Hover	100	107	110		x		23.0"	3200	
Normal cruise	100	104	107		x		24.0"	3200	
Maximum cruise	105	109	113		x		24.0"	3200	
DOORS-OFF									
Ground idle	94	104	109		x		10.5"	2200	
Ground high power	101	107	109		x		13.7"	3200	
Hover	103	107	110		x		23.0"	3200	
Normal cruise	102	108	115		x		24.0"	3200	
Maximum cruise	106	112	118		x		24.0"	3200	
EXT HIGH POWER									
0	92	101	105				13.7"	3200	50'
30	93	100	103						
60	98	104	107						
90	99	106	109						
120	101	109	112						
150	102	109	113						
180	102	112	114						
HOVER									
0	93	101	104				23.0"	3200	50'
30	94	100	103						
60	98	103	106						
90	101	107	109						
120	103	109	113						
150	107	112	115						
180	103	111	114						

ANNEX A

Paragraph C

HEADQUARTERS
UNITED STATES ARMY AVIATION SCHOOL
FORT RUCKER, ALABAMA

AASDI 12 November 1963

SUBJECT: Off-the-Shelf Helicopter Mission Suitability Tests

TO: President
United States Army Aviation Test Board
Fort Rucker, Alabama

1. Inclosed corrected evaluation reports forwarded per your request.

2. This correspondence is marked "For Official Use Only" solely because of the addition of the inclosures. When the inclosures are removed, protective markings will be canceled.

FOR THE COMMANDANT:

/s/ M. J. Fayard
/t/ M. J. FAYARD
2d Lt. AGC
Asst Adjutant General

4 Incls
1. IH-1 Helicopter
2. IH-2 Helicopter
3. IH-3 Helicopter
4. IH-4 Helicopter

EVALUATION OF MISSION SUITABILITY OF THE IH-3 HELICOPTER AS CONDUCTED BY THE UNITED STATES ARMY AVIATION SCHOOL

1. Scope.

a. The IH-3 Helicopter was flown by Rotary Wing Instrument instructors from Department of Rotary Wing Training, US Army Aviation School (USAAVNS), for the purpose of evaluating its potential as a basic instrument trainer. This evaluation was conducted on the basis that the trainer is for use as a simulated instrument flight trainer only. Actual instrument flight capability was not considered. Tests were conducted in the vicinity of Fort Rucker, Alabama, performing basic maneuvers taught in the Army Helicopter Instrument Course.

b. The test aircraft and instruments furnished for evaluation were not of the configuration proposed as the final product by the manufacturer. The comments contained in this report pertain to the configuration of the test aircraft when modified by the manufacturer's technical proposal.

2. Findings.

a. Cockpit Configuration.

(1) Instrument Location. Satisfactory.

(2) Instrument Suitability. Unsatisfactory. The AR-1C attitude indicator proposed incorporates an integrated attitude indicator, and turn slip indicator. The turn indicator needle does not have the capability to indicate a steep turn because of limited needle travel.

(3) Radio Control Location. Satisfactory.

(4) Switch and Auxiliary Control Location. Unsatisfactory. The collective pitch friction device was not located in a position easily accessible to the student pilot.

(5) Night Lighting. Undetermined. Suitability of instrument lighting could not be determined because the proposed configuration was not furnished for evaluation.

(6) Seating. Satisfactory. The left and center seating of the actual test vehicle is not considered acceptable. Seating proposed in the IH-3 is satisfactory.

(7) Storage Space. Satisfactory. Detailed location of available storage space was not included in the manufacturer's technical proposal; however, the cabin size seems large enough to accommodate satisfactory storage provisions.

(8) Instrument Training Hood. Undetermined. Drawings of the instrument training hood in the manufacturer's technical proposal appear to provide a satisfactory approach to the problem of providing an instrument training hood. A mockup of the hood was not provided, therefore, a determination of its suitability could not be made.

b. Flight Characteristics. The IH-3 Helicopter was flown at weights varying from normal operating weight to maximum certificated gross weight. Maneuvers normally required for basic rotary wing instrument training were performed with particular attention toward controllability and in-flight stability.

(1) Controllability. Unsatisfactory. Cyclic and collective control forces are too great for the precision adjustments that are required for attitude instrument flying. It was extremely difficult to zero cyclic control forces with the cyclic trim device.

(2) In-flight Stability. Unsatisfactory. The IH-3 Helicopter was evaluated as to stability in pitch, roll, and yaw. Stability of the air during flight test varied from smooth to moderate turbulence. Definite yaw instability was found to exist in light turbulence, and was most prevalent at low speeds, and/or low power settings. This resulted in rapid oscillation of the turn indicator. Pitch, roll, and yaw were considered unsatisfactory in moderate turbulence.

(3) Basic Maneuver Performance. The following discrepancies were noted, in addition to those listed above:

(a) Large attitude changes were required for transition from a hover to cruise speed.

(b) To perform left turns, a nose low attitude indication was required to maintain level flight.

(c) To perform right turns, a nose high attitude indication was required to maintain level flight.

(4) Proposed Radio Electronic Configuration. Unsatisfactory. The IH-3 proposal indicates that the AS-580-A antenna will be used for the VOR and ILS antenna. The proposed location is outside the aircraft, on the bubble top.

Previous Army Aviation School experience with this antenna, installed on helicopters, has been unsatisfactory. Tests conducted by Stanford Research Institute, and the United States Army Signal Aviation Test and Support Activity, confirm the unsuitability of this type antenna.

These tests indicate that the problem of rotor modulation in helicopter installations can be solved by use of a split loop type antenna such as the AS1304 (Dorne-Margolin DMN 4-4) installed in an optimum location.

3. Conclusions.

a. The IH-3 Helicopter as proposed, was found to be unsuitable in the area of mission suitability.

b. It is estimated that major design changes would be required to correct the deficiencies and shortcomings noted in the IH-3 Helicopter.

Paragraph C

BAAR-P 6 September 1963

SUBJECT: USABAAR's Evaluation of IH-3 Off-the-Shelf Basic Instrument Trainer

TO: President
U. S. Army Aviation Test Board
ATTN: Off-the-Shelf Project Officer
Fort Rucker, Alabama

1. The following is USABAAR's evaluation of the IH-3 for the off-the-shelf basic instrument trainer competition. The evaluation considered the categories of aviation safety and accident prevention in three primary categories. In each of these categories, USABAAR found the aircraft to be acceptable for its intended mission. However, there are certain deficiencies which will detract from its mission capability and should be considered by those responsible for selecting the winner of the competition. Categories considered are:

a. Operational Safety - This category considers those features of the aircraft and its operating characteristics that are considered to be conducive to accident causation and which may detract from the operator's ability to maintain safe flight at all times.

b. Maintenance Safety - This category considers maintenance design features of the aircraft contributing to accident causation. It includes those features of "Murphy's Law," ease of inspection, accessibility for component replacement, the preflight inspections imposed on the operator, etc.

c. Crashworthiness - This category considers design features of the aircraft that, in the event of a crash, provide protection to the occupants from injury. It also includes features of crash-fire worthiness.

BAAR-P 6 September 1963
SUBJECT: USABAAR's Evaluation of IH-3 Off-the-Shelf Basic Instrument Trainer

2. Evaluation comments are as follows:

a. Operational Safety

(1) There are excess control forces on the collective pitch which would result in pilot fatigue.

(2) The tail boom "Pogo" stick is not substantial.

(3) The tail rotor has no guard extending beyond the blades which would prevent personnel from walking into them.

(4) The main skid shoes are not full length.

(5) There is insufficient leg room between the pilot's collective pitch control and the copilot's cyclic control. This causes interference with the controls.

(6) The cyclic control contacts the seat cushion.

(7) The instrument labels are not standardized, i.e., some are positioned on top of the instruments and some underneath. The labels should be embossed as well as painted.

(8) The heater air intake valve is located in close proximity to the engine exhaust which will allow fumes to enter the cockpit during downwind hovering.

(9) The manual cargo foot release is situated so that it could easily be inadvertently actuated.

b. Maintenance Safety

(1) Continuous read-out chip detectors are not provided in the engine or transmission systems.

(2) There are inadequate provisions for "step here" areas on which to stand while pre-flighting the rotor head.

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SUBJECT: USABAAR's Evaluation of Off-the-Shelf Basic Instrument Trainer

c. Crashworthiness

(1) Shoulder harnesses with inertial reels have not been provided.

(2) There is no overhead protection for personnel in the event of a crash in which the aircraft turns over.

(3) The seat belt buckles are of a civilian design which is inadequate for Army standards.

3. If the above noted items are corrected by the manufacturer's proposal, they will no longer be considered discrepancies.

4. The following features are recognized as desirable and considered worthy of mention:

a. The number of post-crash fires of the basic IH-3 airframe construction has been negligible as evidenced by accident records on file in USABAAR.

b. The emergency exits and releases are well marked and suitable for quick egress.

c. The range of external vision from the cockpit is excellent.

/s/ Robert M. Hamilton
/t/ ROBERT M. HAMILTON
Colonel, Infantry
Director, USABAAR

Paragraph D

U. S. ARMY AVIATION HUMAN RESEARCH UNIT
Fort Rucker, Alabama

20 August 1963

Human Factors Evaluation of IH-3 Helicopter for the Basic Instrument Training Mission

1. Summary

1.1 The human factors design of the IH-3 was found to be adequate for mission accomplishment with the exception of the method for trimming out cyclic stick forces.

2. Detailed Considerations

The aircraft was regarded as acceptable from the human factors standpoint with the exception of the consideration listed below.

2.1 The cyclic stick force trim control is unique within the Army helicopter inventory, and will result in certain instrument control habits materially different from those of the Army helicopters. With the IH-3 corrections tend to be made by moving the cyclic stick with separate lateral and longitudinal "beeps" of the trim switch. With other helicopters, the cyclic stick is moved manually, and stick forces reduced to zero by depressing and releasing the force trim release switch. Since many of the control actions in basic instrument training will involve trim adjustments, the IH-3 trim system is considered undesirable for a basic instrument trainer. It will establish control habits materially different from those required in other tactical helicopters. This will result in additional training time required to transition to the system of tactical helicopters. In addition, in emergency situations there is a possibility of reversion to the initially established IH-3 control habits, producing inappropriate control responses for the situation.

/s/ Robert H. Wright, Ph.D.
/t/ ROBERT H. WRIGHT, Ph. D.
Research Scientist

UNIT D - COMPANY C MODEL IH-4

SECTION ONE

USAAVNTBD REPORT

A. Description of Materiel.

1. The IH-4 is a single-engine, two-place, side-by-side, three-bladed single main-rotor- and tail-rotor-type helicopter. Power is supplied by an HIO-360-B1A horizontally-mounted, four-cylinder, opposed-type air-cooled non-supercharged, fuel injection engine which has a maximum power rating of 180 b.hp. at 2900 r.p.m. Engine power is transmitted to the rotors through drive shafts, a belt drive, and reduction gears. The lower pulley of the belt drive is connected to the engine. The upper pulley is mounted on the main gear box pinion, the end of which is also splined to the tail-rotor drive shaft. The belt-drive assembly incorporates an idler pulley, controlled from the cockpit, which acts as a clutch for engaging and disengaging the engine from the rotor.

2. Flight controls consist of a cyclic stick, collective pitch stick, and antitorque pedals. Electrically operated bungees are provided for longitudinal and lateral cyclic trim control. Adjustable friction devices are provided for the cyclic and collective pitch. A yaw computer/actuator is installed which provides low authority yaw stabilization.

3. The main rotor is fully articulated and utilizes three all-metal rotor blades. A two-bladed antitorque tail rotor mounted on a delta hinge provides a means for directional control.

4. The fuselage components are attached to the central framework of steel tubing. The seat, floor, and main rotor mast support structure form a detachable unit and are fabricated from sheet metal. A tail boom is fabricated from a single piece of aluminum tubing. A transparent plastic canopy, tinted overhead, is provided. A skid-type landing gear incorporates oleo-type struts between cross tubes and skids. Conventional ground-handling wheels are removable and are normally positioned at the front of the skids for flight.

5. General dimensions of the helicopter submitted for test are listed below:

a.	Overall height	8 feet 3 inches
b.	Overall length (main rotor tip to tail rotor tip)	28 feet 5 inches
c.	Rotor diameter	25 feet 4 inches
d.	Fuselage width	4 feet 3 inches
e.	Skid gear tread (maximum)	6 feet 7 inches

B. Scope of Tests. The test was conducted in the vicinity of Fort Rucker, Alabama, by USAAVNTBD project officers and USAAVNS rotary-wing instrument instructor personnel. The test consisted of three phases: a 25-flying-hour evaluation; a thorough study of the manufacturer's technical proposal which described changes to be made to configure the test helicopter to meet the stated requirements; and a comparison of the helicopter with the Model Specification and the Statement of Requirement. In addition, the US Army Board for Aviation Accident Research (USABAAR) evaluated the aviation safety aspects; the US Army Aviation Human Research Unit (USAAHUMRU) evaluated the human factors aspects; and the US Army Aeromedical Research Unit (USAARU) evaluated noise level, internal lighting, and heating and ventilation. Complete reports as received from each of these units are contained in section two.

C. Tests.

1. Evaluation of Physical and Flight Characteristics, Performance, Mission Suitability, and Maintenance.

a. Physical Characteristics.

(1) Basic and Operating Weights. The helicopter was weighed as delivered with oil and trapped (unusable) fuel. To this weight (1015 pounds), the weight of electronic and auxiliary equipment required for Army use (188 pounds) was added, and the weight of currently-installed equipment not required for Army use (43 pounds) was subtracted, resulting in a total estimated basic weight of 1160 pounds. The estimated mission operating weight was then computed by adding to the estimated basic weight the weight of fuel (150 pounds) and 450 pounds (instructor, student, and instructional equipment). Details follow:

EMPTY WEIGHT as weighed (less ground-handling wheels)		1015 lb.
Required equipment to be added:		
Shoulder harness and inertia reel (2 ea.)	4	
First-aid kit and fire extinguisher*	10	
AN/ARC-45 (UHF)	25	
C-1611 interphone (2 ea.)	4	
VOR, Type 15F	27	
ADF, Type 21A	23	
MB/GS	9	
RMI Converter, B-18A	4	
Inverters	14	
Flux valve	2	
Battery, MA-7	34	
Generator, 28 volt, 50 amp.	15	
Heater	11	
Antenna, AT-450/ARC	1	
Instrument training hood (estimated)*	5	
TOTAL ADDED	188 lb.	188 lb.
		1203 lb.

*No provisions were made for this weight in the manufacturer's estimate of mission operating weight.

WEIGHT (brought forward)		1203 lb.
Installed equipment to be removed:		
Commercial radio	7	
Generator, 12 volt	15	
Twelve-volt battery	21	
TOTAL SUBTRACTED	43 lb.	-43 lb.
TOTAL BASIC WEIGHT (estimated)		1160 lb.
Fuel		150 lb.
Instructor pilot, student, and instructional equipment		450 lb.
MISSION OPERATING WEIGHT (estimated)		1760 lb.
MAXIMUM CERTIFICATED GROSS WEIGHT		1670 lb.
MANUFACTURER'S ESTIMATED MISSION OPERATING WEIGHT		1670 lb.

To obtain the proposed estimated mission operating weight, the manufacturer was required to deviate from the electronic configuration required by the Model Specification by substituting lightweight avionic items. No information was available to determine their suitability. Deviations from Table "E" of the Model Specification are listed below:

Model Specification	Proposed
ICS, C-1611 (2 each)	ICS, C-1611 (1 each)
VOR, Type 15F	VOR, ARC 319A
ADF, Type 21A	ADF, ARC 318A
MB/GS, Collins/Babcock	Marker Beacon, ARC 502A

Model Specification	Proposed
RMI, C-6-H	RMI, C-6-X
Battery, MA-7	Battery, CA-10H
Inverter, MG-E-93-200 (2 each)	Inverter, Static, SI-121 (2 each)

(2) Ground-Handling Characteristics. Ground-handling characteristics of the helicopter were satisfactory, utilizing the removable ground-handling wheels provided with the helicopter.

(3) Adequacy of Cockpit Configuration and Arrangement. The cockpit configuration and arrangement of the test helicopter were evaluated except for those items changed in the manufacturer's technical proposal. The cockpit configuration and arrangement were satisfactory except for the following:

(a) The rotor-engage lever was accessible from the student pilot station (right seat) only and could not be operated from the instructor pilot station (left seat).

(b) The engine could be started with the rotor-engage lever in the engage position which could result in damage to the main rotor system.

(c) The location of cyclic friction controls (longitudinal and lateral) was unsatisfactory. Friction controls were accessible from the student position only.

(d) Installed seat belts did not meet the Military Specification.

(e) Airspeed indicator provided was not graduated in knots.

(f) Doors were not jettisonable.

(g) A mixture control of the push-pull vernier screw type was provided in the test helicopter. Since the fuel injection system installed does not lean automatically, a cruise leaning procedure was recommended using the vernier screw capability. No provisions were

made to limit the leaning process to preclude accidental fuel starvation of the engine.

(h) An ammeter measuring the charge-discharge rate of the battery was provided in lieu of a load meter (volt-ammeter) measuring the load on the generator.

(i) The engine instrument group consisted of six rectangular gauges, approximately 1 inch by 1 1/2 inches. This type of display does not allow for rotation of the instruments to the 9 o'clock or 3 o'clock needle position to facilitate a rapid cross-check.

(4) Noise Level. Overall internal and external sound pressure levels were acceptable. However, many of the internal measurements exceeded the military specifications for acoustical noise levels in Army aircraft (paragraph A, section two).

(5) Suitability of External Lighting. External lighting was satisfactory and met all Model Specification requirements with the exception of the landing light which was not adjustable. However, the manufacturer's technical proposal indicated the landing light would be ground adjustable.

(6) In-Flight Visibility. Excellent all-around visibility from the instructor pilot seat was provided except for the obstruction of the pilot and copilot door frames.

(7) Ventilation. Ventilation was adequate. For details, see paragraph A, section two.

(8) Suitability for Hoisting, Jacking, and Mooring. The helicopter was equipped with suitable hoisting and jacking points and had suitable locations on the structure for attachment of mooring lines.

(9) Center-of-Gravity Travel. The CG of the helicopter remained within limits without addition of ballast or relocation of components regardless of changes in loading of the helicopter with respect to fuel, instructor pilot, and student.

b. Flight Characteristics. The helicopter was flown at various weights up to the maximum certificated gross weight of 1670 pounds. Maneuvers normally required of a rotary-wing basic instru-

ment trainer were performed with particular attention toward controllability and in-flight stability. The flight characteristics of the IH-4 as a basic instrument trainer were unsatisfactory because of the following:

(1) Controllability.

(a) The cyclic trim device in the IH-4 Helicopter did not provide adequate travel to zero the longitudinal control forces. Because of this limitation, cyclic control forces were excessive. Precise trim adjustments required for attitude instrument flying were very difficult due to the nature of the motoring trim device.

(b) Aircraft attitude response to small cyclic control movements was excessive. This sensitivity could cause the student to overcontrol.

(c) The IH-4 was equipped with a yaw damper which provided limited heading control. Operation of the yaw damper, which was of the autopilot type, resulted in movement of the control pedals. This pedal movement required continual pilot pedal pressures to damp the input introduced by the yaw damper. A limited torque setting in the yaw damper provides a means for the pilot to override the servo output.

(2) In-flight Stability. Stability of the IH-4 was evaluated in pitch, roll, and yaw. Smooth to lightly turbulent air was encountered during the flight test period. With the yaw damper on, the helicopter exhibited unsatisfactory stability about all axes. Increased yaw instability was experienced without the use of the yaw damper.

(3) Autorotational Characteristics. Aircraft flight characteristics during autorotative entry were unsatisfactory. When the collective pitch was lowered rapidly, simulating engine failure, the helicopter pitched forward, and rolled left resulting in an unusual attitude. Before the student could interpret the instruments and apply necessary corrections, a dangerous condition could develop.

c. Performance. The helicopter was flown at the maximum certificated gross weight (1670 pounds) to determine whether it met the performance criteria in the model specification. The following were determined:

(1) Maximum cruise airspeed (true) at 5000 feet m. s. l. (standard conditions) was 71 knots (Vne).

(2) Endurance at 5000 feet m. s. l. (standard conditions) at 70 knots (true airspeed) was 2. 1 hours when using the recommended cruise leaning procedure outlined in the FAA-approved flight manual. *

d. Maintenance.

(1) During the evaluation, the helicopter was maintained by the manufacturer's representative with military personnel provided for servicing, general assistance, and maintenance of records.

(2) No provisions were made for quick-disconnect of the battery.

(3) Engine operation on standard Army aviation fuel (115/145 octane) was satisfactory.

(4) The engine was not operated on standard Army aviation lubricants (detergent oil was used to coincide with commercial operation).

(5) The helicopter was easy to service and maintain with exception of oil servicing. The location and size of the oil filler neck opening necessitated the use of a small, long-neck container. All major components were readily accessible; however, no replacements were required during the evaluation.

(6) Tools and ground-support equipment normally found at the organizational level were adequate for organizational maintenance of this helicopter. Special tools are required for higher echelons of maintenance.

*Use of a cruise leaning procedure for basic instrument training is unsatisfactory. Many altitude and power changes are required which would necessitate "full-rich" operation. The recommended leaning procedure required full attention of the crew to obtain the maximum economy fuel setting. Considerable training time would be lost if repeated leaning of the mixture were needed. Endurance at 5000 feet m. s. l. (standard conditions) at 70 knots (true airspeed) was 1. 95 hours when operating at a "full-rich" mixture.

2. Evaluation of Manufacturer's Technical Proposal. A thorough study was made of the manufacturer's technical proposal which described changes to re-configure the test helicopter to meet the stated requirements. The following were determined:

a. Adequacy of the Cockpit Configuration and Arrangement.

(1) A map light was not provided.

(2) An on-off switch was not provided for the flight instruments, which could result in an excessive power drain during engine starting.

(3) Only one C-1611 interphone control was proposed in lieu of the two required (appendix I, Model Specification).

(4) FAA Approved Flight Manual, Model IH-4, dated 23 August 1963, indicates 400 pounds maximum gross in cockpit. The Model Specification requires a cockpit load capability of 450 pounds. Manufacturer's technical proposal did not authorize an increased cockpit load.

(5) Seat belts and shoulder harnesses with inertia reels for all occupants were included in the technical proposal; however, suitability could not be determined.

(6) Floor-mounted and cyclic-control-mounted radio-interphone switches were provided for both student pilot and instructor. A two-position ICS/transmit switch was not included in the technical proposal.

(7) Storage space in this aircraft was very limited. The map case and the space inside the back seat cushion were inadequate.

(8) Drawings of the "Fixed Instrument Training Hood" in the manufacturer's technical proposal appeared to provide a satisfactory approach for an instrument training hood. The proposed "Collapsible Instrument Training Hood" was considered unsuitable. A detailed evaluation of either instrument training hood was not conducted because hood mockups were not provided.

b. Suitability of External Power Receptacle. The helicopter was equipped with an external power receptacle compatible with Army APU's.

c. Suitability of Internal Lighting. The cockpit and instrument panel illumination of this helicopter did not meet Army standards for an instrument trainer capable of performing night training missions (paragraph A, section two).

d. Heating. A heater was not installed on the test helicopter, but an exhaust muff-type was proposed.

e. Instrumentation and Panel Arrangement Proposal.

(1) The manufacturer's proposal for a production panel configuration and instrument arrangement was satisfactory except for the turn-and-slip indicator. The use of the proposed attitude indicator (GH-211) with an integral horizontal bar turn-and-slip indicator was considered unsuitable. If operating on partial panel, no reference would be available to determine the rate of turn when greater than standard rate, because the maximum travel of the turn indicator is limited to turns slightly greater than standard rate.*

(2) A manifold pressure indicator and engine tachometer were provided.

(3) Instrument panel was configured in a front-mounted panel, standard "T" arrangement in the technical proposal.

(4) All instruments required by the Model Specification under the navigational group were provided in the technical proposal.

(5) Switches and auxiliary controls necessary for flight and navigation as shown in the technical proposal were accessible and within reach of the student and instructor pilots.

*The manufacturer provided a breadboard installation of a similar five-inch attitude indicator which included a four-minute turn-and-slip indicator. The turn needle in this installation was dampened to the point of being unusable. The needle lagged aircraft movements by 8 to 12 seconds. The indicator without the use of a damper would have been difficult to interpret because of the helicopter yaw instability.

(6) The radio control panel as shown in the technical proposal was accessible, both visually and physically, to the student and instructor pilots.

(7) The radio magnetic indicator proposed did not conform to appendix I of the Model Specification. A C-6-X RMI was proposed in lieu of the C-6-H listed. The indicator proposed is capable of simultaneous readout of VOR and ADF navigational radios and is considered suitable.

(8) No information was available to determine suitability of the proposed SPC-1 heading reference.

f. Mission Suitability. The IH-4 Helicopter as proposed was unsatisfactory in the area of mission suitability. (See paragraph B, section two, for the complete report from the USAAVNS.)

g. Electronic Configuration. The helicopter provided for evaluation was not equipped with the electronic equipment specified in appendix I of the Model Specification. The manufacturer's proposal submitted with the helicopter specified the location and installation of all proposed electronic components. The proposed electronic configuration was unsatisfactory because of the following:

(1) Inverters included in the technical proposal did not conform to appendix I of the Model Specification. One SI-121 static inverter was proposed in lieu of the inverters listed. A second SI-121 static inverter will be installed in the GH-211 attitude indicator. No information was available on the reliability or durability of the proposed inverters.

(2) A CA-10H battery was proposed in lieu of the MA-7 battery listed in appendix I of the Model Specification. No information was available on the reliability or durability of the proposed battery.

(3) Non-standard navigational equipment was proposed in lieu of the required items specified in appendix I of the Model Specification. No information was available to determine suitability.

(4) A 28-volt, 50-amp. generator was proposed for power supply. Power required to operate all electrical systems simultaneously approaches the maximum capacity of the generator.

h. Aviation Safety. The evaluation considered the categories of operational safety, maintenance safety, and crashworthiness. USABAAR considers this helicopter to be unacceptable as a basic instrument trainer in the areas of operational safety and crashworthiness due to the discrepancies listed in the USABAAR report which is contained in paragraph C, section two.

i. Human Factors. The human factors design of the IH-4 was adequate for mission accomplishment with the exception of the method for trimming out cyclic stick forces (paragraph D, section two).

3. Comparison with Model Specification and Statement of Requirement. The extent to which the IH-4 met the requirements of the Model Specification and Statement of Requirement was determined by consideration of the characteristics of the helicopter as tested and an evaluation of the manufacturer's technical proposal.

a. Comparison with Model Specification as Amended.

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
1.	SCOPE.		
1.1	Scope. This detail specification covers the essential requirements for the design of a single engine Helicopter Basic Instrument Trainer capable of performing the mission specified in 1.2.		
1.1.1	Designation and General Description. Army Model Designation - Helicopter Basic Instrument trainer (model number not yet assigned).		

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
	Number of crew - 1 pilot	Yes	
	Number of passengers - 1 student	Yes	
	Crew and passenger seating arrangement - side by side (instructor pilot on the left).	Yes	
	Flight controls - dual	Yes	
	Main rotor system - single	Yes	
1.2	Mission. The primary Army mission for which this helicopter will be employed is training of military pilots in helicopter instrument flying. Training will be accomplished under simulated instrument flight conditions.	No	See USAAVNS report for complete details (paragraph B, section two).
1.3	Federal Aviation Agency Certification. The helicopter will have a Part 6 standard airworthiness certificate issued by the Federal Aviation Agency.	Yes	
1.4	Performance Information. Those items of performance stated as requirements herein which are not included in the FAA approved flight manual are subject to verification by the U. S. Army.	Not Required	
2.	APPLICABLE DOCUMENTS.		

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
2.1	The documents applicable to this specification are those necessary to fulfill the requirements of paragraph 1.3, Federal Aviation Agency Certification.	Yes	
3.	REQUIREMENTS.		
3.1	Basic Weight. The basic weight of the helicopter will include all required installed equipment including the Avionics as stated in paragraphs 3.7.1, 3.8.1.1, 3.8.1.2, and 3.10.1.	No	Lightweight avionic equipment was substituted for required equipment.
3.2	Center-of-Gravity Travel. Addition, removal or relocation of ballast or aircraft components will not be necessary in order to maintain the CG within CG limits due to changes in loading of the helicopter with respect to fuel, pilot and student.	Yes	
3.3	Required Performance.		
3.3.1	NASA Standard Day Conditions (at certificated gross weight).		
	Cruise speed (minimum) - 70 knots at 5000 ft. m.s.l.	Yes	Maximum cruise speed obtained was 70 knots (V_{ne}).

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
	Endurance (minimum) - 2 1/2 hours at 70 knots cruise speed at 5000 ft. m. s. l.	No	Maximum endurance was 2. 1 hours utilizing cruise leaning procedure (paragraph C1c(2)).
3. 3. 2	Useful Load. The useful load of the helicopter will be sufficient for 450 pounds in addition to fuel and oil necessary to accomplish the 2 1/2 hours endurance performance mission specified in paragraph 3. 3. 1.	No	Using equipment required by appendix I of Model Specification prohibits helicopter meeting specification.
3. 4	Aircraft Structure.		
3. 4. 1	Landing Gear.		
3. 4. 1. 1	Type Landing Gear. Type of landing gear is optional.	Yes	Skid-type gear with oleo struts was utilized.
3. 4. 1. 2	Ground Handling. Ground handling wheels are required. Weight of the ground handling wheels will not be included in the weight empty if they are detachable.	Yes	
3. 4. 1. 3	Hoisting, Jacking and Mooring. Provisions will be made for hoisting, jacking and mooring.	Yes	
3. 5	Operating Environment.		

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
3.5.1	Aircraft Operation. The aircraft will be capable of operating in temperatures from 0°F. to +100°F.	Undetermined	Manufacturer's Technical Proposal indicated helicopter is capable of operation in temperatures from 0°F. to +100°F. Temperatures during test period varied from +75°F. to +95°F. No difficulties were noted.
3.5.2	Cabin Heating. The aircraft will have a heating system which provides a minimum of 50°F. cabin temperature, with 0°F. outside air temperature. This condition need only be satisfied with the engine operating.	Undetermined	An exhaust muff-type heater was included in the technical proposal.
3.5.3	Defrosters. This aircraft will include defrosters on both sides of the windshield.	Yes*	
3.6	Fuel and Lubricants. The engine will operate on such fuel and lubricants which are now established as standard by the US Army. (Reference: MIL-G-5572C	Yes*	The IH-4 was operated on 115/145 octane gasoline and detergent oil during conduct of the test. The

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
	dated 12 July 1960, MIL-L-22851 dated 30 July 1961 and MIL-L-6082C dated 18 May 1961).		manufacturer's proposal indicated that the helicopter would operate on Army nondetergent oil.
3.7	Instruments and Navigational Equipment. Flight instruments and lights for day and night VFR flight conditions will be furnished and installed by the contractor. Standard "T" arrangement, front mounted panel, is required. Instrument panel will be arranged to permit unobstructed vision of instruments by the instructor pilot and student pilot.	No*	Instrument lighting proposed was unsatisfactory. Engine instrument group was unsatisfactory.
3.7.1	Navigational Group. The following instruments are required:		
	Attitude indicator - five-inch, non-precessing, non-tumbling type.	Yes*	The indicator must have adequate pitch and roll adjustment.
	Heading Indicator - Three-inch, radio magnetic indicator (RMI) type.	Yes*	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
	Vertical Speed Indicator - Instantaneous type.	Yes*	
	Altimeter - Sensitive, barometric.	Yes	
	Airspeed Indicator - (indicated in knots)	No	Graduation on the airspeed indicator was not specified in technical proposal. A m.p.h. indicator was provided in the test helicopter.
	Turn and Slip Indicator - Four-minute turn needle	Yes*	Incorporated in GH-211 attitude indicator but considered unsuitable.
	Magnetic Compass - Located for easy reference by student pilot and instructor pilot.	Yes*	
	Clock - Elapsed time.	Yes*	
3.7.2	Power Group.		
	a. For reciprocating engine: a manifold pressure indicator and engine/main rotor tachometer are required.	Yes	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
	b. For turbine engine: a gas producer indicator, torquemeter, and engine/ main rotor tachometer are required.	N/A	
3.8	Electrical.		
3.8.1	Lighting.		
3.8.1.1	Anti-Collision Light. The aircraft will have an anti-collision light. The light will be located to prevent reflection into the cockpit.	Yes	
3.8.1.2	Landing Light(s). The aircraft will be equipped with landing lights which will be adjustable. The landing light switch will be located on the pilot's cyclic or collective controls.	Yes*	The landing light installed was not adjustable but a light manually adjustable on the ground was included in technical proposal.
3.8.2	Power Receptacle. The aircraft will be equipped with an external power receptacle of an AN or AMS standard design.	Yes*	
3.8.3	Switches and Auxiliary Controls. All switches and	No*	Rotor-engage lever and cyclic

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
	auxiliary controls necessary for flight and navigation will be accessible and within reach of the student pilot and the instructor pilot.		friction controls were not accessible to instructor pilot.
	Switches and controls shall be operable in flight by personnel wearing winter flight clothing.	Yes*	
	Accessible floor mounted and cyclic control mounted radio-interphone switches will be provided for both student pilot and instructor.	Yes*	
3.9	Other Equipment and Requirements.		
3.9.1	Instrument Training Hood. A permanent type hooded device which will allow the student to observe the instruments and not allow observance outside the aircraft will be provided. This device will not obstruct the vision of the instructor pilot.	Undetermined*	No mockup was provided. See paragraph B, section two, for complete details.
3.9.2	Safety Equipment. Seat belts and shoulder harness	Yes*	

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
	for all occupants will be provided.	Yes*	
3.9.3	Control Pedals. Adjustable control pedals will be provided.	Yes	
3.9.4	Storage Space. Storage space for navigational equipment such as maps, charts, computers and navigational kit (TM 11-2557) will be provided.	No*	Storage space provided was inadequate.
3.10	Avionics.		
3.10.1	Electronic Equipment. The aircraft will be equipped with electronic equipment as indicated in appendix I.	No*	Lightweight substitute items have been proposed.
3.10.2	Radio Control Panel. Must be accessible, both visually and physically to the student pilot and the instructor pilot. Overhead location is not acceptable.	Yes*	
	APPENDIX I.		

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
	Communication.		
	UHF - AN/ARC-45, 1 each	Yes*	
	ICS - C-1611, 2 each	No*	One C-1611 proposed.
	Navigation.		
	VOR - Aircraft Radio Corp. Type 15F, 1 each	No*	ARC 319A proposed.
	RMI Converter - ARC Type B-18A, 1 each	No*	ARC B-19A proposed.
	ADF - Aircraft Radio Corp. Type 21A, 1 each	No*	ARC 318A proposed.
	MB/GS - Collins/Babcock, 1 each. (Marker Beacon Glide Slope Receiver to be commercial counterpart of R-844 if available.)	No*	ARC 502A proposed.
	Heading reference, 1 each (Contractor selected and furnished systems having capabilities equal to or superior to Army Standard J-2 compass (commercial C-4). Equipment will be furnished with C-6H indicator. The selected system shall be qualified to FAA Technical Standard Order C6C and shall bear TSO Type A certification decals.)	Undetermined*	No information was available to determine suitability of the proposed SPC-1 heading reference.

*Not tested; included in technical proposal.

Mod. Spec. Para. No.	Model Specification as Amended	IH-4 Meets Spec.	Remarks
	Instrumentation.		
	RMI - Sperry C-6-H, 1 each.	No*	C-6-X proposed is capable of simultaneous read-out of VOR and ADF navigational radios and is considered suitable.
	Miscellaneous.		
	Antenna - Collins AT-450/ ARC, 1 each	Yes*	
	Battery - Sonotone MA-7, 1 each	No*	CA-10H battery proposed.
	Inverter - Leland MG-E-93-200 or Bendix 328-172-1, 2 each.	No*	SI-121 static inverters were proposed.

b. Comparison with Statement of Requirement. A comparison with the Statement of Requirement (reference 3), excluding those requirements covered by the Model Specification, follows:

Performance. Unless otherwise specified, the following should be attained at NASA standard conditions with an instructor pilot, one student pilot and fuel for 2.5 hours endurance at normal cruise.

Requirement	IH-4 Meets Requirement	Remarks
Cruise airspeed (standard day) 5,000' m.s.l. (knots):		

*Not tested; included in technical proposal.

Requirement	IH-4 Meets Requirement	Remarks
Essential - 70 Desired - 90	Yes No	Maximum cruise speed obtained was 71 knots which was also Vne.
Endurance (at cruise airspeed) 5,000' m.s.l., no reserve (hours):		
Essential - 2.5 Desired - 3.5	No No	Maximum endurance obtained was 2.1 hours using cruise leaning procedure (paragraph C1c(2)).
Stability - Adequate yaw, roll and pitch stability in light to moderate turbulence.	No	See USAAVNS report for details, paragraph B, section two.
Cabin Arrangement.		
Windshields constructed of material highly resistant to scratching.	Yes	Latest state-of-the-art material is used for bubble. No scratches were acquired during conduct of evaluation.
Warning lights on panel to include fuel, oil, hydraulic and electrical systems (desired).	No	Warning lights on fuel and transmission were provided in the proposal.
Earphone and microphone jacks and cords compatible with APH-5 helmet for all occupants.	Yes*	

*Not tested; included in technical proposal.

Requirement	IH-4 Meets Requirement	Remarks
Personnel Considerations.		
No new personnel skills will be required.	Yes	Due to similarity to other helicopters in the Army, no additional personnel skills are required.
Training Considerations.		
No new training requirements will be generated.	Yes	No new training requirements for technical service schools are required.
No supporting training devices other than those on hand at the US Army Training Base are required.	Yes	

D. Deficiencies and Shortcomings.

1. The following deficiencies were noted during conduct of the evaluation:

a. Helicopter did not satisfy the endurance requirements shown in the Model Specification.

b. Estimated useful load available did not meet Model Specification when utilizing required electronic equipment.

c. Cockpit and instrument panel illumination did not meet Military Standards.

d. Adequate stability in light-to-moderate turbulence was not provided.

e. The engine could be started with the rotor-engage lever in the "engage" position.

f. The cockpit doors were not jettisonable.

g. Cyclic control forces were excessive.

h. The proposed turn-and-slip indicator was unsuitable.

i. Aircraft was found unsatisfactory in the area of crashworthiness.

j. Cyclic motoring trim device was unsuitable.

k. Maximum cabin load authorized was 400 pounds. Model Specification required a cabin load capability of 450 pounds.

l. Adequate storage space was not provided.

m. Friction controls were not accessible from instructor crew station.

n. Rotor-engage lever was not accessible from instructor pilot station.

o. No provisions were made for a map light to read approach plates.

2. The following shortcomings were noted during conduct of the evaluation:

a. No provisions were made for quick-disconnect of the battery.

b. A stop was not provided on the mixture control to prevent accidental fuel starvation.

c. Method of cockpit and instrument panel illumination did not meet Military Standards.

d. An ammeter measuring battery charge or discharge was installed in lieu of a load meter (volt-ammeter) desired.

e. Cockpit instrument lighting reflects instruments in canopy.

f. Graduations on the airspeed indicator were in m.p.h.

g. Instruments and radio control panel lighting could not be independently controlled.

h. Engine instrument group was unsatisfactory.

i. Cockpit door frames restricted visibility.

j. Oil servicing neck location and size were unsatisfactory.

k. A separate on-off switch was not provided for flight instruments.

l. Luminous paint and ultraviolet light was used to illuminate instrument dials.

m. A two position ICS/transmit switch on the cyclic stick was not included in the technical proposal.

n. Engine exhaust was located approximately 15 inches from the ground and acted as an ignition source when operating in areas of tall dry grass.

o. Short skid shoe installation exposed skids to catching on ground objects.

p. Adjustment for the antitorque pedals was unsatisfactory.

q. Pitch change push-pull rods are susceptible to damage from being used as hand holds.

r. Magnetic chip detectors were not installed in the transmission and engine oil sumps.

s. Seat pan energy absorption in the vertical direction appeared to be unsatisfactory.

t. The storage space inside the back seat cushion was accessible for storing items that could contribute to crash injury.

u. The design and position of the cyclic stick made it lethal in the production of injury.

v. Seat belt attaching point was not self-aligning in all directions which would make it vulnerable to failure when lateral loads were applied.

w. The cockpit lacked structural members that will prevent impingement upon the occupants in the event of a crash.

x. The fuel cell design was susceptible to rupture and its immediate proximity to ignition sources created a post-crash fire hazard.

SECTION TWO

Reports from Other Agencies on the IH-4

Paragraph A

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama 36362

USAARU-FO 23 September 1963

NOISE EVALUATION OF THE IH-4

1. Methods and Equipment.

a. Due to the number of aircraft to be tested and the short time available, the noise analysis was limited to the following:

(1) "A" - 24-55 db: sound level for speech interference.

(2) "B" - 55-85 db: sound level for noise survey.

(3) "C" - 85-140 db: sound pressure level--over-all frequency response.

b. A General Radio, Sound-Level-Meter, type 1551-C, was used for the noise measurements.

c. The test area, located at County Line Strip, is a pre-marked compass rose with a 50 foot radius.

2. Results. (See Annex A)

3. Discussion.

	Doors On	Doors Off	MIL-A-8806
Normal cruise	113	113	106
Maximum cruise	112	113	113

a. Operation of this helicopter at normal cruise with the cockpit doors on or off produces internal sound pressure levels in excess of Table I MIL-A-8806.

b. Operation of this helicopter at maximum cruise with the doors on or off produces internal sound pressure levels which meet the limits set by Table IV MIL-A-8806.

USAARU-FO 23 September 1963
SUBJECT: Noise Evaluation of the IH-4

c. There are no military specifications for external noise. Raw data is included for comparison purposes only.

4. Summary. Improvements should be made to reduce noise levels when operating at normal cruise in order to meet military specification (MIL-A-8806).

/s/ William C. Thrasher
/t/ WILLIAM C. THRASHER
1/Lt., MSC
Ass't Chief, Avn Fld Opns Div

1 Incl
as

NOISE LEVEL MEASUREMENTS-OCTAVE BAND ANALYSIS

DATA COLLECTION SHEET

Analyzed by Lt. W. C. Thrasher
SFC Lonnie Parsons

Date 20 Sep 63

IH-4

DOORS-ON	A	B	C	Center	Student	Air Speed	Mani-fold	RPM	Radius
Ground idle	93	101	109				12.5"	2000	
Ground high power	98	104	109				15.5	2900	
Hover	101	105	110				25	2900	
Normal cruise	102	106	113			70 mph	24	2900	
Maximum cruise	103	108	112			86 mph	27.5	2900	
DOORS-OFF									
Ground idle	95	108	116				12.5	2000	
Ground high power	100	107	112				15.5	2900	
Hover	103	110	115				25	2900	
Normal cruise	101	108	113			70 mph	24	2900	
Maximum cruise	102	108	113			86 mph	27.5	2900	
EXT HIGH POWER							15.5	2900	50'
(RIGHT)				(LEFT)					
0	96	96	99	0	91	96	99		
30	90	94	97	330	92	97	100		
60	90	94	97	300	91	94	97		
90	91	95	99	270	92	95	98		
120	95	98	100	240	94	98	101		
150	97	101	103	210	96	101	104		
180	96	101	105	180	96	101	105		
HOVER							25"	2900	50'
(RIGHT)				(LEFT)					
0	93	96	97	0	93	96	97		
30	95	96	98	330	94	97	99		
60	94	97	101	300	94	98	101		
90	97	99	101	270	98	100	103		
120	102	102	105	240	102	103	107		
150	104	107	110	210	104	107	109		
180	101	105	109	180	101	105	109		

EXHAUST OUTLET RIGHT SIDE OF AIRCRAFT

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama 36362

USAARU-FO 23 September 1963

LIGHT EVALUATION OF THE IH-4

1. Methods and Equipment.

a. The evaluation consisted of in-flight analysis of the aircraft's lighting system under night conditions. Criteria for this evaluation were derived from U. S. Navy Specifications governing cockpit and instrument panel illumination modified to meet Army requirements.

b. A standard Norwood photo-electric meter was used to measure overall cockpit illumination from the auxiliary hand light or map light.

2. Results. (See Annex A)

3. Discussion.

a. Luminous paint and ultraviolet light used to illuminate instrument dials and gauges afford adequate light intensity but impair visual acuity. The extreme contrast between the black, light absorbing background of the dials and the luminous markings can cause discomfort and distraction to an inexperienced aviator.

b. The airspeed indicator, the rotor tachometer, the altimeter and the manifold pressure gauge were unreadable at night due to the position of the flight instrument panel.

c. When the instrument panel lights were adjusted to adequately illuminate the instruments, a great amount of light was reflected from the bubble into the pilot's eyes. With the instrument panel lights turned off, a complete panel of luminous dials and gauges was reflected in the bubble.

d. An auxiliary light or map light should be placed in the cockpit to aid in navigation and to furnish light in case of electrical failure of the instrument panel lighting circuit.

USAARU-FO 23 September 1963
SUBJECT: Light Evaluation of the IH-4

4. Summary. At present the cockpit and instrument panel illumination of this aircraft does not meet the military standards for a primary or instrument trainer capable of performing night training missions.

/s/ William C. Thrasher
/t/ WILLIAM C. THRASHER
1/Lt., MSC
Ass't Chief, Avn Fld Opns Div.

1 Incl
as

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama

COCKPIT LIGHT STUDY
IH-4

1. Are all instruments adequately illuminated? No (Note para 3a)

2. Are they illuminated uniformly? No (Note para 3b) Is there sufficient intensity? No

3. Is illumination controllable to very low intensities? Yes (Aperature Change)

4. Are markings of instruments readable? No (Note para 3b)

5. Are all controls, instructions, and nameplates adequately illuminated? No

6. Are they illuminated uniformly? No Is there sufficient intensity? No

7. Is illumination controllable to very low intensities? No (Note para 3c)

8. Are markings on controls, instructions and nameplates readable? No

9. Is the intensity of lighting for some instruments and controls controlled separately? No

10. Is an auxiliary light provided? No

11. Are there any sources of light which give other than standard red light? Yes

12. Are there any reflections in the windshield, windows, canopy or other reflecting surfaces which interfere with visibility inside or outside the cockpit? Yes (Note para 3c)

13. Are spare lamps provided in sufficient quantity and easily accessible? No

ANNEX "A"

14. Are all instruments, instructions, nameplates, and control markings readable in daylight? Yes

15. Can warning and caution lights be dimmed sufficiently for night operations? No (Landing light indicator could not be dimmed)

16. Are warning and caution lights of sufficient intensity for daylight use? Yes

17. Are warning and caution lights on the main dimming circuit? No

18. Is the auxiliary light adequate for reading? No

19. Is there adequate general illumination for the compartment? No (Note para 3d)

20. Do any of the exterior lights provide glare in the cockpit? Yes

21. Is exterior lighting provided in accordance with FAA? Yes

Aviation Field Operations Division
U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama

USAARU-FO

25 June 1963

REPORT ON IH-4

1. Method of Testing.

a. The heating and ventilation evaluation of the IH-4 consisted of comparisons of outside air temperature and cockpit air temperature with the aircraft under all operating conditions. In conjunction with these checks, a carbon monoxide test was also made.

b. Equipment consisted of:

(1) Weston Aneroid Thermometer, Model 2291.

(2) Mine Safety Appliance Company Carbon Monoxide Tester, Category No. DS-47133.

2. Results. (See Annex A)

3. Discussion.

a. Although reasonably high temperatures were encountered on the aircraft with doors on, windows closed and vents closed (see Annex A), it is felt that this aircraft will rarely be operated under those conditions with existing outside temperatures in the 90°F. range.

b. The recommended maximum temperatures for clothed men not especially acclimatized are as follows:

(1) Resting in still air - 88°F.

(2) Resting, with some air movement (170 FPM air velocity) - 93°F.

(3) Moderate work, still air - 78°F.

USAARU-FO 25 June 1963
SUBJECT: Report on IH-4

Reference: Patty, Frank A., Industrial Hygiene & Toxicology (2d ed., Vol. 1;
New York: Interscience Publishers Inc., 1958).

c. Comparing recommended working temperatures (see above) with temperatures found in aircraft (see Annex A), a mean working temperature of 90°F. was derived. This is felt to be within limits.

d. A small percentage of carbon monoxide (.01) was found in the aircraft with the doors on, windows closed, vents closed, and the aircraft on the ground at operating RPM. This amount is not felt to be significant and rarely will aircraft be operated on the ground with doors on, windows closed, and vents closed.

e. A heater was not present on this aircraft.

/s/ J. C. Rothwell
/t/ J. C. ROTHWELL
Captain, MSC
Ass't Chief, Avn Fld Opns Div

1 Incl
as

HEATING AND VENTILATION EVALUATION OF OFF-THE-SHELF HELICOPTER TRAINERS

Analyzed by Capt. Rothwell Date 14 June 1963

IH-4

	%CO		Temp	
	A/C	Out	A/C	Out
VENTILATION				
On Ground				
Doors Off (P)	0	0	94°F	90°F
Doors On - Window Closed, Vent Open	0	0	96°F	90°F
Doors On - Window Closed, Vent Closed	0	0	98°F	90°F
Hover				
Doors Off (P)	0	0	92°F	90°F
Doors On - Window Closed, Vent Open	0	0	94°F	90°F
Doors On - Window Closed, Vent Closed	.01	0	96°F	90°F
In-Flight				
Doors Off (P)	0	0	90°F	87°F
Doors On - Window Closed, Vent Open	0	0	92°F	82°F
Doors On - Window Closed, Vent Closed	0	0	94°F	82°F

HEATING*

*Heater not present on this aircraft.

ANNEX "A"

Paragraph B

HEADQUARTERS
UNITED STATES ARMY AVIATION SCHOOL
FORT RUCKER, ALABAMA

AASDI 12 November 1963

SUBJECT: Off-the-Shelf Helicopter Mission Suitability Tests

TO: President
United States Army Aviation Test Board
Fort Rucker, Alabama

1. Inclosed corrected evaluation reports forwarded per your request.

2. This correspondence is marked "For Official Use Only" solely because of the addition of the inclosures. When the inclosures are removed, protective markings will be canceled.

FOR THE COMMANDANT:

/s/ M. J. Fayard
/t/ M. J. FAYARD
2d Lt. AGC
Asst Adjutant General

4 Incls
1. IH-1 Helicopter
2. IH-2 Helicopter
3. IH-3 Helicopter
4. IH-4 Helicopter

EVALUATION OF MISSION SUITABILITY OF THE IH-4 HELICOPTER AS CONDUCTED BY THE UNITED STATES ARMY AVIATION SCHOOL

1. Scope.

a. The IH-4 Helicopter was flown by Rotary Wing Instrument instructors from Department of Rotary Wing Training, US Army Aviation School (USAAVNS), for the purpose of evaluating its potential as a basic instrument trainer. This evaluation was conducted on the basis that the trainer is for use as a simulated instrument flight trainer only. Actual instrument flight capability was not considered. Tests were conducted in the vicinity of Fort Rucker, Alabama, performing basic maneuvers taught in the Army Helicopter Instrument Course.

b. The test aircraft and instruments furnished for evaluation were not of the configuration proposed as the final product by the manufacturer. The comments contained in this report pertain to the configuration of the test aircraft when modified by the manufacturer's technical proposal.

2. Findings.

a. Cockpit configuration.

(1) Instrument location. Satisfactory.

(2) Instrument suitability. Unsatisfactory. The turn slip indicator integrated in the AR-1C attitude indicator in the test aircraft was found to be unsuitable. The turn needle travel was insufficient to provide indications of a steep turn. The turn needle in this installation was damped to the point of being unusable. The needle lagged aircraft movement by 8 to 12 seconds. The manufacturer indicates the proposed Sperry GH211 display is identical to the AR-1C.

(3) Radio Control Location. Satisfactory.

(4) Switch and Auxiliary Control Location. Satisfactory.

(5) Night lighting. Undetermined. Suitability of the instrument lighting could not be determined, because the proposed configuration was not furnished for evaluation.

(6) Seating. Satisfactory.

(7) Storage space. Unsatisfactory. Storage space in this aircraft is very limited. The map case provided in the proposal does not furnish satisfactory storage space.

(8) Instrument Training Hood. Undetermined. Drawings of the "Fixed Instrument Training Hood" in the manufacturer's technical proposal appears to provide a satisfactory approach for an instrument training hood. The proposed "collapsible instrument training hood" is considered unsuitable. A detailed evaluation of either instrument training hood could not be conducted because hood mockups were not provided.

b. Flight Characteristics. The IH-4 Helicopter was flown at weights varying from normal operating weight to maximum certificated gross weight. Maneuvers normally required for basic rotary wing instrument training were performed with particular attention toward controllability and in-flight stability.

(1) Controllability. Unsatisfactory.

(a) The cyclic trim device in the IH-4 Helicopter did not provide adequate travel to zero longitudinal control forces. Because of this limitation cyclic control forces were excessive; in addition, precise trim adjustments required for attitude instrument flying were very difficult.

(b) Aircraft attitude response to small cyclic control movements was excessive. This sensitivity would cause the student to overcontrol.

(c) To improve yaw stability, the IH-4 was equipped with a yaw damper which provided a limited heading control. Operation of the yaw damper, which was of the autopilot type, resulted in movement of the control pedals. This pedal movement required continual pilot pedal pressures to damp the input introduced by the yaw damper. A limited torque setting in the yaw damper provides a means for the pilot to superimpose his directions on the servo output. These conditions are unsatisfactory for basic instrument instruction.

(2) In-flight stability. Unsatisfactory. Air stability during flight test varied from smooth to light turbulence. This aircraft, which was equipped with a yaw damper, exhibited unsatisfactory stability about all axes. Increased yaw instability was experienced without the use of the yaw damper.

AD-A031 888 ARMY AVIATION TEST BOARD FORT RUCKER ALA F/G 1/3
MILITARY POTENTIAL TEST OF COMMERCIAL OFF-THE-SHELF HELICOPTERS--ETC(U)
NOV 63 W S DAVIS, J F COMER

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(3) Basic Maneuver Performance. The following discrepancies were noted in addition to the problems reported above:

(a) Simulated instrument takeoffs are considered too hazardous due to the low inertia rotor system. The performance of this maneuver requires high engine power, in excess of 28 Hg manifold pressure, combined with very low airspeed for approximately the first 100 feet. An engine malfunction during this period would be extremely dangerous. The Federal Aviation Agency imposed a 26" Hg manifold pressure power setting limit below 300 feet.

(b) Aircraft flight characteristics during autorotative entry are unsatisfactory. When the collective pitch is lowered rapidly, simulating engine failure, the aircraft pitches forward, and rolls left to a dangerous condition before the student flying instruments can interpret the attitude and apply necessary corrections.

(c) Large attitude changes were required for transition from a hover to cruise speed.

(d) To perform left turns, a nose low attitude indication was required to maintain level flight.

(e) To perform right turns, a nose high attitude indication was required to maintain level flight.

(4) Proposed Radio Electronic Configuration. Unsatisfactory. Radio navigation equipment proposed in the IH-4 Helicopter does not conform to the equipment listed in the appendix I of the Model Specifications as required.

3. Conclusions.

a. The IH-4 Helicopter as proposed was found to be unsuitable in the area of mission suitability.

b. It is estimated that major design changes would be required to correct the deficiencies and shortcomings noted in the IH-4 Helicopter.

Paragraph C

BAAR-P 30 September 1963

SUBJECT: USABAAR's Evaluation of IH-4 Off-the-Shelf Basic Instrument Helicopter Trainer

TO: President
U. S. Army Aviation Test Board
ATTN: Off-the-Shelf Project Officer
Fort Rucker, Alabama

1. The following is USABAAR's evaluation of the IH-4 entry for the off-the-shelf basic instrument helicopter trainer competition. The evaluation considered the categories of aviation safety and accident prevention in three primary categories. In each of these categories, there are certain deficiencies which will detract from its mission capability and should be considered by those responsible for selecting the winner of the competition. Categories considered are:

a. Operational Safety - This category considers those features of the aircraft and its operating characteristics that are considered to be conducive to accident causation and which may detract from the operator's ability to maintain safe flight at all times.

b. Maintenance Safety - This category considers maintenance design features of the aircraft contributing to accident causation. It includes those features of "Murphy's Law," case of inspection, accessibility for component replacement, the preflight inspection imposed on the operator, etc.

c. Crashworthiness - This category considers design features of the aircraft that, in the event of a crash, provide protection to the occupants from injury. It also includes features of crash-fire worthiness.

2. Evaluation comments are as follows:

a. Operational Safety

(1) Clutch engagement - No provisions are included to prevent starting the engine with the clutch engaged to prevent damper and rotor head damage.

(2) Engine instrument group - The mounting angle of the instruments makes readout difficult.

(3) Intercom system - A two position ICS/Transmit switch should be located on the cyclic control to preclude the need to remove hands from control grip in event of emergency.

(4) Pilot distraction and loss of visibility - The instruments are mirrored in the bubble during day and night. The light angle and the reflection characteristics of the bubble are such that during night and day operations, the instrument panel is noticeably visible in the bubble.

(5) Navigation lights - The light positioned above the bubble creates detracting reflections on the bubble at night. The modification that relocates the lights on the skid assembly appears to be more satisfactory.

(6) Instruments - Instrument legibility becomes blurred and difficult to read at night when using the landing light during final approach and hover. This deficiency is particularly noticeable when the instrument light is partially dimmed.

(7) Map light - There are none installed or proposed. Map lights should be installed to preclude the use of makeshift lights.

(8) Landing Light - The fixed landing light causes excessive glare on the bubble when operating close to the ground.

(9) Transmission and pressure warning lights - The labels of these displays are not visible to the pilot.

(10) Engine exhaust - It is located approximately 15 inches from the ground and acts as an ignition source when operating in areas of tall dry grass.

(11) Skid shoe - The short skid shoe installation exposes skids to catching on ground objects. Installation of full length skid shoes is required to preclude snagging ground objects.

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(12) Autorotation characteristics - The autorotation characteristics are such that more skill is required to perform this maneuver than is presently needed in any other helicopter presently in the Army inventory. USABAAR is of the opinion that this factor alone would make this helicopter unacceptable as a basic instrument helicopter trainer.

(13) Cyclic control - Upon entering autorotation an unusually excessive amount of aft cyclic control is necessary to maintain desired air speed.

(14) Cyclic trim control - When flying at or near gross weight, there is insufficient amount of forward cyclic trim.

(15) Anti torque pedal - The adjustment for the anti torque pedals is unsatisfactory.

b. Maintenance Safety

(1) Pitch change push-pull rods - The pitch change push-pull rods from the lower bell cranks to the main rotor system are susceptible to damaging lateral loads when used as hand holds. Their accessibility makes the occurrence very likely.

(2) Magnetic chip detector - Chip detectors of the continuous readout type should be installed in the transmission and engine oil sumps.

c. Crashworthiness

(1) Seat pan - Energy absorption in the vertical direction appears to be unsatisfactory. This is based on the amount of space available before the seat pan "bottoms out."

(2) Seat back rest.

(a) The space behind the back rest is accessible for the storing of odd items such as clipboards, tools, handbooks, etc. These items can contribute to crash injury.

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(b) The energy absorption qualities of the thermoplastic material are unknown as to the extent that it may protect occupants against injury.

(3) Cyclic control - The design and position of the cyclic control makes it lethal in the production of injury.

(4) Shoulder harness and inertia reel - Any aircraft procurement must include these items to be acceptable to USABAAR.

(5) Seat belt - The attaching point is not self-aligning in all directions which makes it vulnerable to failure when lateral loads are applied.

(6) Cockpit integrity - The cockpit lacks structural members that will prevent impingement upon the occupants in the event of a crash.

(7) Fuel cell - The cell design is susceptible to rupture. Its immediate proximity to ignition sources creates a post-crash fire hazard.

3. The following features are recognized as desirable and considered worthy of mention:

a. Cyclic and pitch control forces are negligible.

b. The range of external vision from the cockpit is excellent.

c. The throttle and pitch controls are well correlated.

d. The design and the inspection requirements of this aircraft makes it easy for the pilot to perform his preflight.

e. The landing gear design was found to have some outstanding characteristics. Forces applied to the landing gear during hard landings are not transmitted to the basic airframe structure.

/s/ Robert M. Hamilton
/t/ ROBERT M. HAMILTON
Colonel, Infantry
Director, USABAAR

Paragraph D

U. S. ARMY AVIATION HUMAN RESEARCH UNIT
Fort Rucker, Alabama

13 September 1963

Human Factors Evaluation of IH-4 Helicopter
for the Basic Instrument Training Mission.

1. Summary

1.1 The human factors design of the IH-4 was found to be adequate for mission accomplishment with the exception of the method for trimming out cyclic stick forces.

2. Detailed Considerations

The aircraft was regarded as acceptable from the human factors standpoint with the exception of the consideration listed below.

2.1 The cyclic stick force trim control will result in certain instrument control habits materially different from those of other Army helicopters. With the IH-4, corrections tend to be made by moving the cyclic stick with separate lateral and longitudinal "beeps" of the trim switch. With certain other helicopters the cyclic stick is moved manually, and stick forces reduced to zero by depressing and releasing the force trim release switch. Since many of the control actions in basic instrument training will involve trim adjustments, the IH-4 trim system is considered undesirable for a basic instrument trainer. It will establish control habits materially different from those required in other tactical helicopters. This will result in additional training time required to transition to the system of tactical helicopters. In addition, in emergency situations there is a possibility of reversion to the initially established IH-4 control habits, producing inappropriate control responses for the situation.

/s/ H. Alton Boyd, Jr.
/t/ H. ALTON BOYD, JR.
Research Associate

HABjr/nsb

PART III - LIST OF REFERENCES

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2. Message, Department of the Army, ODCSOPS/Army Aviation #328665, 8 January 1963.

3. Letter, AMCMR-MO-A, US Army Materiel Command, 1 April 1963, subject: "Procurement of 'Off-the-Shelf' Training Helicopters" with inclosure (revised Statements of Requirement).

4. Letter, OPS AVMD, Headquarters, Department of the Army, 26 November 1962, subject: "Replacement of Tactical Aircraft with Off-the-Shelf Commercial Aircraft," with one inclosure.

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7. Letter, SMOSM-PAIF, US Army Aviation and Surface Materiel Command, 31 May 1963, subject: "Amendment to Invitation for Bids, IFB No. AMC(T)-23-204-567 (Step One)."

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11. Plan of Test, USATECOM Project No. 4-3-1000-02-A, "Evaluation of Commercial 'Off-the-Shelf' Helicopters as Basic Rotary-Wing Instrument Trainers," US Army Aviation Test Board, 24 May 1963.

12. Company A Model IH-1, Revised Technical Proposal for Basic Rotary-Wing Instrument Trainer IH-1(5), IH-1(3), dated 18 July 1963.

13. Company A Model IH-1 Drawing No. SK-3276, SK-3277, SK-1005, and SK-1006, dated July 1963.

14. Letter, Company A, 7 August 1963, subject: "Step One, IFB No. AMC(T)-23-204-567, Submittal of Revision to Revised Technical Proposal."

15. Letter, Company A, 6 September 1963, subject: "Step One, IFB No. AMC(T) 23-204-567, Submittal of Revision to Revised Technical Proposal."

16. Letter, Company A, 30 September 1963, subject: "Step One, IFB No. AMC(T) 23-204-63-567, Submittal of Revision to Technical Proposal."

17. Company B Helicopter Basic Instrument Trainer Technical Report, #47-099-024, dated 28 June 1963.

18. Company B Basic Instrument Trainer Proposal Summary, dated 28 June 1963.

19. Company B Basic Instrument Trainer Maintenance Summary, dated 28 June 1963.

20. Letter, Company B, 26 July 1963, subject: "Helicopter Instrument Trainer."

21. Message, Company B, Reference IFB No. AMC(T)-23-204-63-567, #D SKA0225, 24 September 1963.

22. Letter, Company C, 15 August 1963, subject: "IFB No. AMC(T)-23-204-63-567 (Step One)."

23. Company C, Report HTC-63-22, 5 August 1963, subject: "Detail Specification IH-4 Helicopter Basic Instrument Trainer."

24. Company C, Report HTC-63-23, 5 August 1963, subject: "Proposal for Helicopter Basic Instrument Trainer."

AD_____ Accession No._____

US Army Aviation Test Board, Ft. Rucker, Alabama. Military Potential Test of Commercial Off-the-Shelf Helicopters as Basic Rotary-Wing Instrument Trainers. Final report, 13 November 1963. USATECOM Project No. 4-3-1000-02-A. 209 pp., no illus. Unclassified report. Four helicopters (IH-1, IH-2, IH-3, and IH-4) were tested to determine which commercial off-the-shelf FAA-certificated helicopters were suitable for use as basic rotary-wing instrument trainers. It was concluded that the IH-1 and IH-2, after correction of deficiencies and shortcomings listed in units A and B, part II of the report, should be suitable for Army use as basic rotary-wing instrument trainers and that the IH-3 and IH-4 are not suitable for Army use as basic rotary-wing instrument trainers. It was recommended that the IH-1 and IH-2 and associated proposals, after elimination of the deficiencies and shortcomings listed in units A and B, part II of the report, be considered qualified for Step Two of the procurement program, and that the IH-3 and IH-4 and associated proposals be considered not qualified for Step Two of the procurement program.

AD_____ Accession No._____

US Army Aviation Test Board, Ft. Rucker, Alabama. Military Potential Test of Commercial Off-the-Shelf Helicopters as Basic Rotary-Wing Instrument Trainers. Final report, 13 November 1963. USATECOM Project No. 4-3-1000-02-A. 209 pp., no illus. Unclassified report. Four helicopters (IH-1, IH-2, IH-3, and IH-4) were tested to determine which commercial off-the-shelf FAA-certificated helicopters were suitable for use as basic rotary-wing instrument trainers. It was concluded that the IH-1 and IH-2, after correction of deficiencies and shortcomings listed in units A and B, part II of the report, should be suitable for Army use as basic rotary-wing instrument trainers, and that the IH-3 and IH-4 are not suitable for Army use as basic rotary-wing instrument trainers. It was recommended that the IH-2 and IH-2 and associated proposals, after elimination of the deficiencies and shortcomings listed in units A and B, part II of the report, be considered qualified for Step Two of the procurement program, and that the IH-3 and IH-4 and associated proposals be considered not qualified for Step Two of the procurement program.